

THE DETERMINANTS OF COFFEE SUPPLY IN GICHUGU
DIVISION IN KIRINYAGA DISTRICT: KENYA

BY
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PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF MASTER OF ARTS IN ECONOMICS OF KENYATTA
UNIVERSITY.

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*The determinants of
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DECLARATION

This research project is my original work and has not been presented for a degree in any other university.

Signature  Date 9th Oct 2002

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This research project has been presented for examination with our approval as University Supervisors.

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ACKNOWLEDGEMENTS

It is a great joy to say

DEDICATION

To Dad (Jackson Gachurai) and
Mom (Nancy Gachurai)
With love.

ACKNOWLEDGEMENTS

It is a great joy to acknowledge all the support that I have been given during the process of carrying out this research. I would like to express my sincere thanks to my supervisors, Mrs. Okeri and Dr.Njuguna for their immeasurable guidance, advice, suggestions, critical comments and encouragement from the initial stages of proposal writing up to the end of this research. May God bless you.

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ABSTRACT

The general objective of this study was to investigate the factors that determine the supply of coffee in Gichugu Division in Kirinyaga District in Kenya. Data were collected from a sample of 67 farmers in Kirima, Kabare and Baragwi locations of Gichugu Division.

The data were analyzed using both descriptive statistics and the use of econometric model. Four versions of the model were estimated. The interpretation of the results was based on regression results that are consistent with economic expectations on the coefficients of the model and their statistical significance. Coffee supply was found to be positively related to expenditure on inputs, the price of coffee received by the farmers, the size of the farmer's household, the number of coffee trees owned and managed by the farmer, and the farmer's off-farm activity. The distance from the farm to the factory and credit extension to farmers in form of loans and school fees were found to be negatively related to coffee supply. Furthermore, the study found that expenditure on farm inputs is the most significant determinant of coffee supply.

Based on the findings of the study, it is recommended that farmers should diversify their farm activities to include activities for example, poultry keeping and zero grazing methods of cattle rearing to supplement their incomes as well as increasing their investment in coffee farming. Credit extension to farmers in form of material farm inputs should be enhanced to boost expenditure on farm inputs in order to increase coffee supply. To increase coffee supply, the government should stabilize the coffee prices to remove the price uncertainties that demotivate farmers to give maximum attention to their coffee farms.

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CHAPTER ONE

INTRODUCTION

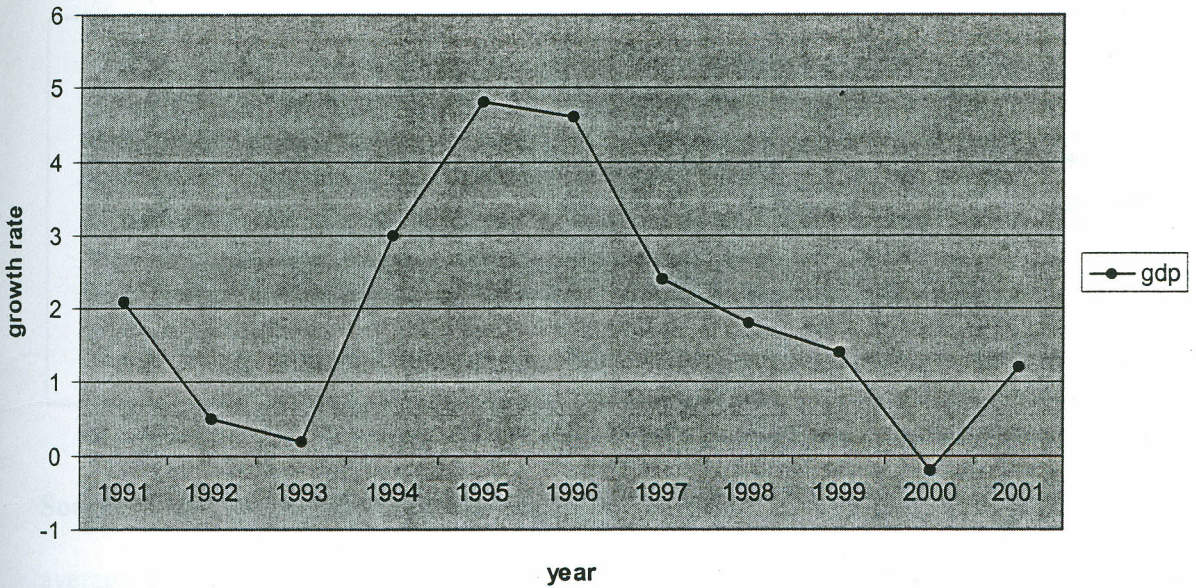
1.1 Overview of Kenya's Agriculture

The agriculture sector in Kenya accounts for about 24.1 percent of the Gross Domestic Product (GDP), employs about 80 percent of the total population and contributes 66 percent of the export earnings while providing for almost all food requirements of the country (Republic of Kenya 1997a). The major export crops grown in Kenya are coffee, tea and horticultural crops while the major food crops include maize, beans and potatoes. The principal production system in Kenya is mainly small-holder agriculture which accounts for 75 percent of the value of agricultural output and 60 percent of the arable land area (Republic of Kenya 1988). Small-holder agriculture also employs 80 percent of the agricultural labour force and contributes a major share of Kenya's agricultural exports (Anker and Knowles 1983).

The Kenyan economy, which is highly dependent on the performance of the agricultural sector has on average been deteriorating since 1973 (Republic of Kenya 1997b). The economy recorded an average of 4.1 percent and 2.2 percent GDP growth rate during the 1980-90 and 1990-99 periods, respectively (World Bank Development Report 2000/2001).

The growth in the country's GDP is presented in Figure 1.1. As can be observed from this figure, the situation was particularly pathetic in the 2000/2001 financial year when the economy recorded a negative growth rate the lowest ever since independence in 1963. However, the government is optimistic that the economy would change its course.

Figure 1.1 GROSS DOMESTIC PRODUCT (GDP) growth rate, 1991-2001



Source: *Economic surveys* (various issues).

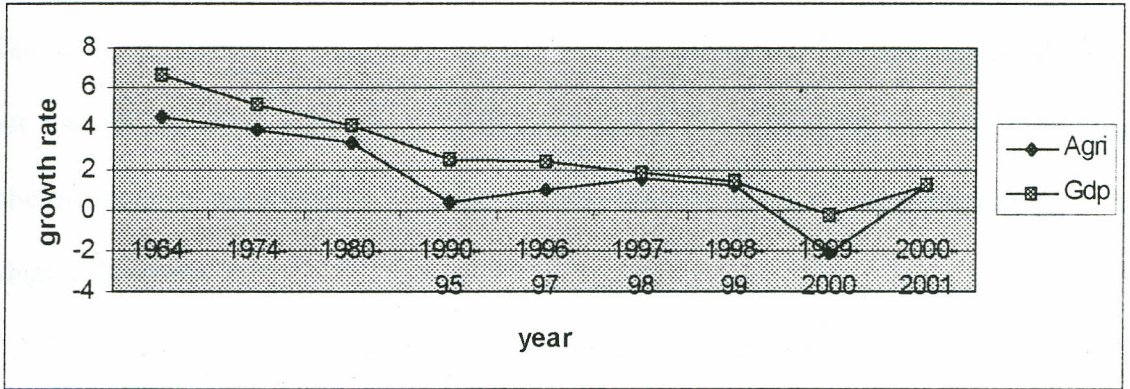
The government has a target of two percent growth rate for 2001/2002 financial year.

Assuming this growth rate is achieved, there should be ways of maintaining a positive rate until a growth rate as high as eight percent, which is needed to attain economic recovery.

This calls for improvement in the agricultural sector since Kenya is highly endowed with good climate and fertile soils for most agricultural crops particularly horticultural crops, coffee and tea, which are some of the major commodity foreign exchange earners.

Kenya's agricultural sector directly influences the overall economic performance through its large contribution to GDP growth. The periods of high economic growth rates have been synonymous with increased agricultural growth. This is shown in Figure 1.2. As can be observed in Figure 1.2, between 1963–73, the agricultural sector recorded an

Figure 1.2 GDP and agriculture sector growth rate 1964-2001(in percent)



Source: *Economic surveys* (various issues).

average annual growth rate of 4.6 percent while an average annual real GDP growth rate of 6.6 percent was observed. Between the years 1974–1980, the agricultural sector recorded an average annual growth rate of 3.9 percent with corresponding annual average real GDP growth rate of 5.2 percent. Between the periods 1980–90 and 1990–95, agriculture recorded average annual growth rates of 3.3 percent and 0.4 percent, respectively and an annual average GDP growth rate of 4.1 percent and 2.5 percent respectively. The agricultural sector growth rate plummeted from 1.2 percent in 1999 to negative 2.1 percent in the year 2000. This again matched the decline in economic growth rate from 1.4 percent in 1999 to negative 0.2 percent in the year 2000. As a result, the total value of agricultural output at current prices declined by 9.9 percent from Ksh.155.6 billion in 1999 to Ksh. 140.2 billion in 2000 (Republic of Kenya 2001). According to 2002 economic survey, in the year 2001 GDP grew at a real rate of 1.2 percent which corresponded with a real growth rate of 1.2 percent in the agricultural sector.

1.1.1 Importance of Coffee in Kenya

The coffee sector provides employment to around 0.5 million producers and even more people are indirectly employed in the output and marketing sectors (Coffee Board of Kenya 1991). Coffee is therefore not only a source of income for the many rural dwellers but also for the other participants in this sub-sector throughout the country. The crop is labour-intensive and therefore it helps to curb the rate of rural urban migration in areas where it is grown.

The export earnings accruing to the rural producers have in the past led to an increase in off-farm income generating activities leading to growth of local industries such as posho mills, saw mills, building and construction only to mention but a few. The export earnings also helped to bridge the gap between the savings and investment and to finance the imports of capital goods and technology. These imports are principally used in the manufacturing sector and importation of farm inputs such as fertilizers, herbicides, pesticides and tractors, which are used in the agricultural sector. The sector has therefore been central to the growth and development of Kenya.

1.1.2 Trade Liberalization and the Coffee Industry

Campaigns to liberalize Kenya's market policies began in 1986 after the realization that the government control of all sectors of the economy including the coffee sub-sector, constrained their development. The policy reforms, which were being campaigned for, were spelt out in the government of Kenya 1986 sessional paper no.1 on "Economic Management for Renewed Growth". This paper was calling for a reduction of the government involvement in the non-strategic sectors of the economy and promotion of the

private sector. As a result of the campaign, trade liberalization was effected in Kenya's coffee sub-sector in 1992.

Due to liberalization, several reforms were made in the coffee sub-sector. These reforms are payment to farmers in foreign currency, holding of foreign exchange retention accounts after removal of foreign exchange regulations, liberalizing the process of delivery to millers and milling, new rules and regulations for coffee brokerage and auctioning, withdrawal of government controls on the Coffee Board of Kenya (CBK) and its exemption from the state corporations act. The major change on the delivery of services to farmers was the exemption of CBK from the corporations Act. This meant the government could no longer manage the CBK. The CBK hence became a farmers' managed organization with powers to regulate and control the coffee industry. All the same modifications of the coffee Act to accommodate these changes have not yet been carried out.

In 1999, through a special issue of the Kenya Gazette Supplement No.7 on the coffee (Authorized Marketing Agents) rules, several changes were made to the legal framework.

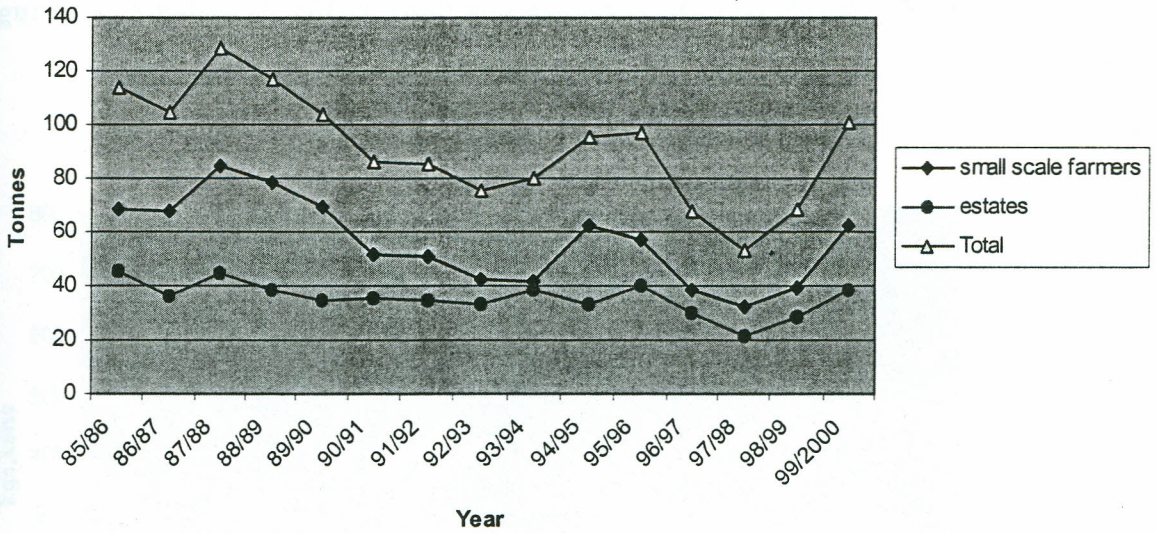
These changes included:

- Revoking of the powers given to CBK for appointing, pulping factories, millers and marketing agents. In its place, planters were bestowed with powers to appoint their own pulping stations, millers and marketing agents. These agents are then registered with CBK.
- Considering a cooperative society was as an agent for the purpose of handling farmers' payment and issuing credit to growers and advances on parchment and cherry.

- Allowing a cooperative society to appoint its own marketing and commission agents for the purpose of handling farmers, payments and providing management, merchandise and other related services.

Further, a coffee factory or coffee cooperative society can deliver its coffee to its chosen miller or authorized marketing agents provided the coffee samples are delivered to the CBK for classification and the coffee is stored in warehouse and offered for sale at the auction. Factories are empowered to change their by-laws to provide for methods of payment, milling and determination of where to mill their coffee and when to auction it. Individuals could also register as cooperative societies but had to concentrate on the stated primary objectives. Despite all the moves by the Kenyan government to improve the coffee sub-sector, the sector has continued to show a falling trend in terms of output as shown in Figure 1.3. Despite the liberalization of the coffee sub-sector in 1992, the coffee sub-sector had continued to show a falling trend in terms of output from 1989 to 1998. Production declined from about 130 thousand tons in 1989 to 53 thousand tons in 1998 (a 59.2 percent decline). The worst decline was on small-scale farms, which accounts for 50 percent of Kenya's coffee production. Currently, the production by small-holders is about 2.5 times

Figure 1.3 Average coffee production by type of farmer in Kenya, 1985-2000



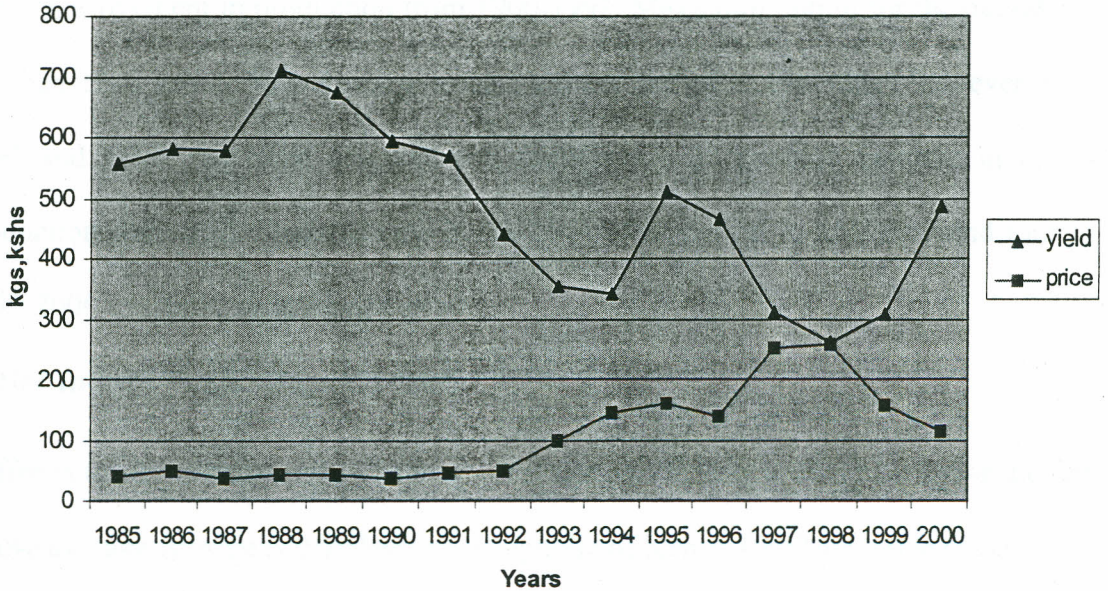
Source: Republic of Kenya (various Issues).

lower than big farms (that is, the production is 400 kg/ha for the small-holders and 1013 kg/ha for big farms).

Due to the decline in production, coffee's contribution to the foreign exchange earnings has also declined and hence a decline in farmers' income and employment. This downward trend has made coffee which was the main foreign exchange earner up to 1986 be ranked fourth behind tea, horticulture and tourism.

Contrary to the decline in coffee production by small-scale farmers for the period (1989-1998), the gross market price for the coffee farmers was generally increasing except for a fall in 1996. Moreover between the years 1998 and 2000, coffee production was increasing while prices were declining as shown in Figure 1.4.

Figure 1.4; Small-scale coffee yield and export prices received by the coffee board of Kenya



Source: *Republic of Kenya* (various issues).

1.1.3 Coffee Production in Kenya

The coffee grown in Kenya is mainly the Arabica species, which occupies nearly 150,000 hectares and produces between 100,000 and 130,000 metric tons of clean coffee annually. (Coffee Board of Kenya vol. 55 no 649). It is grown in the upper midland agroecological zones where the attitude, temperature and deep volcanic soils are well adopted for its growing.

In Kenya, coffee growing is licensed through the Coffee Board of Kenya (CBK) which issues a bulk license to the cooperative societies and the cooperatives distribute the total permissible area among its members. Between 1893-1933 and before the enactment of the coffee act, operations in the coffee industry was a privilege of the settlers only. That is,

only exclusively commercial large-scale farmers within settled areas grew coffee. Although the First World War temporarily disrupted coffee production, coffee output reached 15,000 tons in 1933 as shown on Table 1.1. As can be observed from Table 1.1, there has been some improvement in production from 1900-1992. Maximum output for the periods shown between 1900 and 1992 were improving from one period to the other. However, between 1993 and 2000, the trend changed and there was a 22 percent decrease in maximum production from 130 thousand tons in the 1981-1992 period to 101 thousand tons in the 1993-2000 (trade liberalization) period.

Coffee Industry in Gichugu Division

Coffee is the main cash crop in Gichugu Division and mostly grown by small-scale farmers whose average acreage is 0.99 hectares (Republic of Kenya 1997b). Coffee covers about 40 percent of the total arable land in the division, contributes about 24 percent of the total coffee output in the country and employs about 33 percent of the total population in Gichugu Division, which is about 153,000 people. (Gichugu Division Agriculture Office). Since 1991 the hectareage under coffee has remained constant (7,000ha) and the production has on average continued to decline despite the government's efforts to revive the coffee sub-sector. Although there were no data for the 1991/92 crop year due to failure of some locations to compile their production data, production on average declined by 26.2 percent from 23 million kilograms in the 1993/94-1996/97 crop years to 17 million kilograms in the 1997/98-2000/2001 crop years. In particular, between 1989 and 1998, coffee production in Gichugu division declined from about 28,000 tons to 13,000 tons (54 percent decline) as shown in Table 1.2. As can be observed from Table 1.2 even after trade

Table 1.1 Coffee annual production range

Period	Coffee output (tons)
1900-1933	0-15,000
1934-1954	18,500-24,000
1955-1960	26,000-28,000
1961-1970	30,000-70,000
1971-1980	70,000-80,000
1981-1992	100,000-130,000
1993-2000	80,000-101,000

Source: *Economic Surveys* 1993, 1997 and 2001.

liberalization in 1992, there has not been any major improvement on total production for coffee in Gichugu Division. Production declined by 39 percent from 18 million kilograms in the 1992/93 crop years to 11 million kilograms in the 2000/2001 crop years.

1.2 Statement of the Problem

In the coffee growing areas of Kenya, for instance, Gichugu Division, policies made at the national level usually filter very well to the farm level where their implementation takes place. Through the Coffee Board of Kenya and other organizations such as Kenya Planters Cooperative Union (KPCU), the government has succeeded in introducing the new Arabica Ruiru 11 coffee. The government also allowed for competition in the marketing of coffee by liberalizing coffee trade. A major concern in liberalization of the coffee trade was the need to harmonize the legal framework with policy reform. In particular, the legal framework changed

Table 1.2 Coffee production trends in Gichugu Division 1989-2001.

Year	Total output (kgs)
1989/90	27,690,940.
1990/91	15,766,588.
1991/92	-
1992/93	17,655,620.
1993/94	19,974,998.
1994/95	29,621,066.
1995/96	26,596,086.
1996/97	16,476,186.
1997/98	15,088,123.
1998/99	13,350,095.
1999/2000	28,500,342.
2000/2001	11,403,462.

Source: Gichugu Divisional Agriculture Office.

so that the institutions could fit in well with the new policy framework. Reforms were also made in the coffee processing and milling. Furthermore, farmers were able to start cooperative societies and individual member factories that could deliver their coffee direct to KPCU only to mention a few changes that have been implemented. However, despite these policy reforms and the increase in coffee prices, coffee production has on average continued to decrease over the last few years. The trend in coffee production (representing coffee supplied by the farmer) for the period 1989 - 2001 contradicts the law of supply and particularly for the small-holders who are the majority in Gichugu Division (see Figure 1.4). According to economic theory of supply (various quantities offered for sale at various prices), there is a positive relationship between the price of goods and quantity supplied.

That is, more of a good will be supplied the higher its price, other things constant (Colandar 1993).

The contradicting trend between coffee supplied and prices imply that there could be other factors at the farm level that affect the supply of coffee. However, no attempt has been made so far to investigate why the coffee sub-sector has been characterized by poor performance in the recent years in Gichugu Division, in particular. In view of this the following research questions were asked;

- (i) What are the factors that determine the supply of coffee in Gichugu Division?
- (ii) What is the supply function for coffee in Gichugu Division?
- (iii) In the light of (i) and (ii) above, what policies can be undertaken to enhance the performance of the coffee sub-sector in Gichugu Division?

1.3 Objectives of the Study

The overall objective of the study was to investigate the factors that determine the supply of coffee in Gichugu Division. The specific objectives were:

- (i) To identify the main factors that determine coffee production in Gichugu Division.
- (ii) To estimate the coffee supply function for Gichugu Division.
- (iii) To suggest policies in the light of the study findings on how to enhance the performance of the coffee sub-sector in Gichugu Division in particular and Kenya in general.

1.4 Significance of the Study

A study on the production of coffee in Gichugu Division is important to the people of Gichugu division and the country at large for three main reasons. First, it acts as a reference material for those interested in conducting research in the agricultural sector in Gichugu Division. Second, it provides information on the factors that influence the production of coffee. The results of the study will be helpful to coffee farmers in Gichugu Division, the policy makers, NGO's and donor organizations by giving them useful information on various explanatory variables that may be targeted in the evaluation of policy changes, and provision of new policies in order to enhance the performance of the coffee sub-sector. The good performance can lead to increase in the incomes of the coffee farmers in Gichugu hence an improvement in their standards of living.

Lastly, since agriculture has a direct influence on the economic performance through its contribution to GDP, the study may help to provide useful information to the private and public agencies in designing projects and programmes that can assist the agricultural sector in general and the coffee sub-sector in particular all for the strengthening of Kenya's economy.

1.5 Justification of the Area of Study

Between the period (1989-1998), the percentage decline in coffee production for Gichugu Division (see Table1.2) was equal to the decline in national coffee output (see Section 1.1.2). This similar trend shows that, the policies determined at national level filter well to the farm level where their implementation is expected to take place. Alternatively, a similar trend can be interpreted to mean that the problems that affect the coffee sub-sector

are highly evident in Gichugu Division. This highly qualified Gichugu Division as a good area for carrying out a research to investigate the factors that determine coffee production.

Despite the fact that Gichugu Division is a major coffee producing area with quite a significant contribution to national coffee output, little has been said about this division. This has acted as a motivating factor for carrying out a study to analyze the factors that determine coffee production.

1.6 Scope and limitations of the Study

This study focussed on coffee production in Gichugu Division in Kirinyaga District in the Central Province of Kenya. Due to financial and time constraints, only a reasonable number of farmers from three randomly selected locations were interviewed

1.7 Organization of the Study

Chapter 2 is designed to provide the reader with the literature reviewed. The analytical framework employed in the study is presented and discussed in Chapter 3 and the data sources, analysis and estimation results are detailed in Chapter 4. And lastly, Chapter 5 contains the important findings of the study in relation to the objectives and hypotheses. The chapter also gives the policy implications of the findings.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The theoretical and empirical literature in general indicates the large extent to which attention has been devoted to supply response studies worldwide. However, the subject of coffee supply in Kenya has not received much attention. What follows are some relevant literature from outside and within Kenya.

2.2 Theoretical Literature

According to Commander (1989), supply response in agriculture tends to be formulated in terms of the quantity response to real producer price changes. However, in the context of (macroeconomics) stabilization and adjustment programmes, the supply response needs to be conceptualized in a far broader way. The basic model of the supply response uses the Nerlovian framework where output depends on acreage (A) and yield per acre (μ). Both A and μ depend on expected real producer price(s) and other factors such as weather condition which can be grouped into one variable (Z).

Assuming A represents actual acreage and μ potential yield, a supply response function may be specified as:

$$Q_t = Q_t(\mu_t, A_{t-1}, P_{at}^c, Z_t) \quad (2.1)$$

$$\text{or } Q_t = q_t(\hat{P}_{at}^c, \hat{Z}_t, \lambda) \cdot Q_{t-1} \quad (2.2)$$

where t indicates time or period, P_{at}^c is real producer price, circumflex ($\hat{\ }$) indicates a rate of change, Q_t is output at time t , A_{t-1} is acreage at time $t-1$, Q_{t-1} is output at time $t-1$ and λ is an adjustment coefficient that takes into account the fact that some output in period t may be related to a divergence between actual and desired output in period $t-1$. Equation (2.2) assumes that it may require more than one time period to adjust acreage. Incorporating the structural change increases the efficiency units of Z hence we can have $T.Z$ where T is some index of technical and structural change. Incorporating T as a separate argument yields the equation below;

$$Q_t = q_t (\hat{P}_{at}^c, \hat{Z}_t, T\lambda) \cdot Q_{t-1}$$

The above model in the agricultural sector can be modified in four ways (Commander 1989). This can be done by viewing the sector as one that comprises the following:

- Households that may consume part of their agricultural goods, and allocate their time between leisure, agricultural work and non- agricultural pursuits.
- Agriculture sector that uses bank credit in the marketing and purchase of inputs
- Explicit elements of Z especially technical assistance and other variable inputs such as fertilizers that may be related to extension service of the authorities.
- Domestic marketing costs such as transportation.

In another study, Dillon and Anderson (1990) argued that uncertainty about yield arises because invariably some input variables are not under the decision-makers' control

and their levels are not known at the time decisions are made about the controlled input variables. They classified input factors into;

Decision variables X_1, X_2, \dots, X_n , predetermined variables $X_{n+1}, X_{n+1}, \dots, X_k$ and uncertain variables $X_{k+1}, X_{k+2}, \dots, X_m$ which interacts with X_{is} so that the probability distribution of yield is conditional on X_{is} . No uncertainty attaches to fixed costs F , or the level of the decision variables X_{is} and their unit price P_i . The producer price per unit (P_y) is uncertain reflecting the uncertainty of both P_y and Y . The total profit is defined as;

$$\Pi = P_y Y - \sum P_i X_i - F_1$$

where P_i is input price and is positive for decision variables, $i = 1, \dots, n$ and zero for the uncontrolled variables, $i = n+1 \dots m$, P_y is producer price, Y is output, X_i is decision variables and F_i is fixed cost.

2.3 General Literature

Several studies have been carried out to investigate the relationship between production of different commodities and the factors that determine the level of production. This section presents the literatures according to the factors that affect production.

2.3.1 Commodity Prices

In a study done by Moore (1917) on cotton production, it was found that whereas the current price of cotton was determined by the size of the output in the current year, output itself was influenced by the prices in the previous year. Moore, however, did not consider any other factor as having any influence on production of farm products such as level of education, experience, and farm size among others.

Askari and Cummings (1976) in an analysis for 320 supply price elasticities for Thailand, Chile, India and the United States for a variety of individual crops, found that, irrigation, farm income levels and the rural male literacy rate had a positive and significant effect on the response of farmers to price changes. The price on the other hand was found to have a positive and significant effect on production.

2.3.2 Labour Input

In a study done by Hopcraft (1974) on the effect of formal schooling and technical training on the performance of small-scale maize farmers in Kenya, Hopcraft argued that, labour is less important than land as input in maize production. Purchased inputs were found to be statistically significant factors of production and as expected were more important in the production of hybrid maize than local varieties. The use of hybrid over local varieties was seen to increase output levels substantially; a point estimate of 0.726 was obtained for a hybrid binary variable suggesting that the use of hybrid varieties approximately doubles maize output. Formal schooling beyond three standards was found to have a consistently negative effect on maize production *ceteris paribus*. This was however only confined to the cultivation of local varieties and since there is a positive correlation between the use of hybrids and formal schooling, this suggests that overall impact of education may not be negative. Hopcraft's analysis was on maize production and a similar study on coffee production will be equally important and particularly to analyze the impact of formal schooling on coffee production.

In another study by Mook's (1991) on maize production in male managed farms in Vihiga Division of Western Province labour was found not to be a statistically significant

input (the marginal value product of labour was equal to only 10 percent of the prevailing wage-rate for agricultural labour in the region). Also, one to three years of schooling was negatively related to maize output while four or more years of schooling and extension visits were positively related to output. The extension visits were also found to be effective substitutes for four or more years of schooling (i.e. the coefficient of the interaction term for these two variables was negative and statistically significant and was approximately equal in absolute value to that of extension visits). Mook's found no evidence of any relationship between maize output and either age or migration experience. An analysis of the effect of age on coffee production would be highly important to determine the relationship between the two.

2.3.3 Technology

In Sri-Lanka, Hartley, Nerlove and Peters (1987) in an analysis of rubber supply incorporated the effect of technology (varietal improvement) through the use of yearly empirical estimates of the age yield profile. Statistical results showed that varietal improvements provided the basis for increased levels of replanting of older trees. Studies similar to this have been done before in the coffee sub-sector. It is through such studies that the replacement of the traditional varieties with the new cultivated Arabica variety, Ruiru 11 was recommended. This move was aimed at doubling the coffee output by the year 2000. (Republic of Kenya 1986). However, the year 2000 came and passed without any major improvement in terms of coffee output. This, therefore, necessitates the addressing of other factors like the age of the farmer that can be the cause of the dismal performance of the coffee sub-sector.

In another study by Tomek and Robinson (1991) on supply response for perennial crop production, technology advance was found to be the principal supply shifter. Tomek and Robinson, have however not specified what commodities supply they are talking about. Supply of manufactured goods is most likely to be affected differently by technology as compared to supply of farm products. Again, in farm products, technology has different influence on production depending on whether one is engaged in small or large-scale production or not.

2.3.4 Other Factors Affecting Production

In Ghana, Murthur (1981) carried out a study on supply of cocoa. Murthur found that supply of cocoa was dependent on time. Murthur distinguished changes in supply in the very short period and long period. In the short run, he said that supply could change due to additional variable factors to the fixed factor. That is, the input mix causes changes in supply. On the other hand, he said supply could change due to changes in the scale of production giving rise to either decreasing, constant or increasing supply prices. This depends on the economies and diseconomies of scale. Murthur, however, seems to have given little attention if any to the effect of prices on supply thus giving his research a very weak base. The relativity of the term's short-run and long-run leaves one wondering about the periods where supply function of different products in different countries lie.

Using cross sectional data for 1962-64 and 1968-70 from 53 countries, Peterson (1979) estimated a long-run aggregate supply function. A log liner function was estimated with p , real prices received for all farm products in terms of kilograms of commercial fertilizers that could be purchased with 100 kilograms of wheat equivalent, W , a weather

variable approximated by the long-run annual publications and T , a technology variable approximated by the number of research publications for each country in the sample as independent variable. Peterson found that the long-run aggregate supply elasticity is in the range 1.27 to 1.66. Peterson found that the major constraints that face farmers in developing countries are absence or imperfection of markets, lack of credit, lack of fertilizers. Lack of water, lack of transport and communication facilities and the social and tenurial structure, in addition to geographical and ecological characteristics, all of which can be removed by raising prices. Peterson also highlighted on the factors that take the nature of public goods such as high yielding seed varieties whose supply can be increased by public policies and not simply by price increases. These factors that take the nature of public goods are not very new in the coffee sub-sector.

2.3.5 Literature Specific to Coffee Production in Kenya

Through the use of data collected from farmers, primary institutions factories, societies and unions in Murang'a, Meru and Kisii districts, and national organizations namely millers and the Coffee Board of Kenya, Nyangito (2000) analyzed the production of coffee under trade liberalization in Kenya. Nyangito found that the factors that affect coffee production at the farm level are low input use, neglect of the farms, low payments to farmers, poor delivery of services by various institutions and lack of credit for production. Nyangito however did not consider factors such as size of the farm and family size that highly affect production of agricultural products such as coffee.

Using an econometric model to describe the supply of coffee in Kenya between 1946-1964, Maitha (1969) hypothesized that area under coffee was a function of expected net profits in the future. Maitha specified the profit function as;

$$\Pi = PQ - wL - sL$$

where, P is Real producer price of coffee; Q is quantity of coffee; W is Real farm wage; L is quantity of labour; S is price of land per acre; and L is gross rate of planting per year.

Profits were maximized through the integral;

$$V = \int_0^{\infty} \{ e^{-rt} [\Pi(t)] + \lambda_0(t) [Q - Q(i, x)] + \lambda_1(t) [x - 1 + \delta x] \} dt$$

where, $Q - Q(i, x)$, $x - 1 + \delta x$ is rate of change of area; V is present value; and r is discount rate.

The aggregate coffee production function was specified under the assumption of constant elasticity of substitution as;

$$Q = \gamma [k (R) x^{-\alpha} + (1-k) (R) L^{-\alpha}]^{-v/\alpha}$$

where, $Q - Q(t)$, $Y - Y(t)$, $X - x(t)$, $L - L(t)$, γ is Parameter for technological change; k is distribution parameter (division of factor/ income); V is degree of homogeneity of the production function; α is Substitution parameter and r is weather parameter.

Marginal production of area (q/x) obtained from the maximization of the profit function was equated to the marginal production of area (q/x) obtained from the aggregate production function to obtain the demand function for area

$$\log x = A - \delta \log (c/p) + \delta (1 + \alpha/v) \log Q^*$$

Akiyama and Trivedi (1987) argued that the vintage capital approach to investigate on production is the preferable option in the perennial crop supply analysis given the heterogeneity of capital stock with respect to yield in perennial crop production. The following supply response was derived from the vintage production function:

$$Q_t = \sum F [K (t, v), L (t, v)] \text{ also}$$

$$K (t, v) = N (t) + R(r)$$

Where, Q_t is total output; $K (t, v)$ is capital stock of vintage at the end of period t with uprooting and removals accounted for; $L (t, v)$ is non-labour inputs; N_t is new planting; and $R(r)$ is replanting. The results showed that new plantings were highly price responsive for both Kenya and Sri-Lanka. Parameter estimates were found to be underestimated; thus long-run references could not be made unambiguously. This was due to absence of additional country specific information.

Mutunga (1994), conducted a study on the supply response by coffee producers in Kenya over the period 1963-1992. This was done using two models namely, the state space approach that utilized the Kalmar-Filtter for estimating long-term relationships and the single equation reduced form estimation procedure for estimating short-term relationships. The yield equation specified below was also estimated.

$$Y_t = \alpha + \beta_1 P_t + \beta_2 I_t + \beta_3 t + e_t$$

where Y_t is yield; P_t is Real producer price of coffee; I_t is Real input price index; t is time trend; and e_t - error term

Mutunga found that, there is a positive relationship between price of coffee and the level of new planting and yield. Mutunga also noted that the 'no pull' policy of coffee in Kenya did not have a detrimental effect upon yield in the short-term. However, the period

considered in the analysis is before the liberalization of the coffee trade. The study also considered performance at macro-level. The current study investigated the factors that determine coffee production after trade liberalization at micro-level (farm level).

2.3.6 Literature Specific to Other Countries

In another analysis on coffee supply response in Brazil, Wickens and Greenfield (1973) used an output and investment equations. The two equations sought to quantify the harvest while the investment function represented the decision to invest. The harvest decision was proxied through a distribution lag on past prices.

$$q_t^p = \sum_{i=0}^n \delta_i I_{t-i}$$

$$I_t = a_0 + a_1 I_{t-1} + a_2 P$$

$$q_t = \gamma_0 + \gamma_1 q_t^p + \sum_{i=0}^m \gamma_i + 2 p_{t-1}$$

where q_t^p is potential production; I_t is investment; P is producer price; q_t is actual production; and δ_i is present yield of past plantings. Due to lack of data, these equations were estimated, together as a single reduced form supply equation:

$$q_t = \sum_{i=0}^n \beta_i P_{t-1} + (1 + \alpha_1) q_{t-1} - \alpha_1 q_{t-2} + k$$

where $\beta_i = \alpha_2 \gamma \delta_i$

The results from the estimation indicated the importance of long lags in the supply of tree crops. The dynamics of coffee supply in Brazil could not be adequately captured by the model because of non-price explanatory variables were not included.

In another study, Saylor (1974) through a modified nerlovian function specified the supply elasticity of coffee in Sao Paulo, Brazil. The nerlovian function was modified by including a dummy variable in the area response function to account for the intercept and slope variations in the supply function for the periods 1948-62 and 1963-70.

$$A_t = \alpha_0 + \alpha_1 A_{t-1} + \alpha_2 P_{t-1} + \alpha_3 T + \alpha_4 D_e$$

where A_t is coffee area; P_t is producer price; T is time trend and D_e is dummy variable.

The area under coffee in Kenya has remained constant at about 170 hectares hence this model may not be very useful for analyzing the factors that influence coffee output in Kenya.

Another study by Knapp (1987), showed that the complex dynamics of perennial crop production could not be adequately covered by a general econometric study. This is because yields, input requirements and the age assumption of the perennials varied over the lifespan of the crops and depended on both exogenous as well as endogenous variables. Thus influencing new plantings, removals, quantity produced and subsequently producer prices. Knapp therefore developed a spatial equilibrium approach where an equilibrium timepath of new plantings, removals, prices and consumption was estimated on the basis of an initial stock and age composition of alfalfa. New planting and replanting were viewed as being a function of time path of future expected prices. Consumption in a given year was assumed to be equal to production plus net imports less the change in carryover stocks, and is given by;

$$C_t = \sum_{i=1}^m Y_i A_{it} + N/t + S_t - [1/(1-\beta)]S_{t+1}$$

where: C_t is consumption; I_t is i^{th} age group in period t ; A_{it} is area under crop; R_{it} is removals; S_t is carryover; m is maximum number of age group categories and β is Storage loss. Area under crop per age group and year was equated to the area under the particular age group in the previous year less removals:

$$A_{i+1, t+1} = A_{it} - R_{it}$$

The competitive equilibrium for this model was determined by solving the optimization problem of maximizing the net benefits equation.

Knapp found that production and area planted were significantly affected by changes in demand and cost conditions. Long-run prices increased with decline in production costs and decreased as yields increased. Area exhibited a cyclical pattern and this was attributed to the crops as well as improperly formed expectations. This model however does not include a production function for yield and thus optimal levels for yield and input could not be determined over time. The model assumes production is under taken primarily for local consumption.

In Cote d'ivoire, Trivedi and Akiyama (1992) sought to analyze the effect of different producer prices levels on production levels, quantity of exports, new planting, removals and tax revenue on cocoa and coffee industries. In the study output function and the new planting and removal function were specified as;

$$Q^p(t,v) = \delta(t,v) K(t,v)$$

$$K(t,v) = K(t-1,v) - R(t,v)$$

where $Q^p(t,v)$ is aggregate production function; $\delta(t,v)$ is aggregate yield profile; $K(t,v)$ is surviving stock of vintage trees and $R(t,v)$ is removal losses.

$$N(t) - N[p^d(t-1)]$$

where $N(t)$ is new planting and $\{p^d(t-1)\}$ is proxy for expected producer prices.

The duo found that producer prices for cocoa and coffee were fixed at 36 percent and 47 percent respectively above the world prices in a bid to encourage production and export revenue. The price stabilization programme caused substantial financial deficits because of the extended periods of a depressed world market.

According to Trivedi and Akiyama, institutionally determined producer prices led to the unwarranted expansion of the cocoa sector relative to the coffee sector because of the more favourable cocoa prices, despite the less favourable future outlook for cocoa. Administered producer prices can create a domestic relative price structure that is out of alignment with domestic production costs if changes in these costs are not taken into account.

Although researchers recommended structural approach to perennial crop supply response studies Elgnaeeb and Florwski (1993) noted that, data on new planting and removals and the age distribution are not usually available. To solve this, they developed an analytical framework for indirectly estimating the number of non-bearing trees from changes in production in Georgia's pecan industry. In this model, new plantings given by I in time t were found to be a function of lagged prices and costs as shown below;

$$I_t = \alpha_0 + \alpha_1 P_{t-1} + \alpha_2 C_t$$

where I_t is new planting in period t ; P_{t-1} is prices of pecan in period $t-1$ and C_t is cost of production in period t .

Output was measured as a summation of the production of different bearing age trees categories and yield per bearing tree. Yield was assumed to increase as trees matured.

$$Q_t = \gamma_0 + \gamma_1 Q^*_t + \sum \beta_i P_{t-1} + \beta_{m+1} C_t + \mu W_t + \phi Q_{t-1} + u_t$$

where Q_t is total output; Q^*_t is potential total output; P_t is prices; W_t is climatic variables; U_t is disturbance error term; C_t is costs of production and γ , β , μ , and ϕ are unknown parameters to be estimated.

The model was estimated using OLS technique. The results indicated no detectable serial correlation and good explanatory power. The impact of past planting on quality supply was insignificant. Lagged pecan prices were related mostly to current plantings and consequently were found to have an influence on the supply of pecans. Increased production in the previous year resulted to lowered output in subsequent years.

The model was tested for its predictive power by estimating the expected new planting in 1929, since data were only available for that year. The model was found to overestimate the number of new planting. The findings however cannot be conclusive since only one year was used to test the models predictive power. However, this model is not the best to use due to its low predictive power. Also, the assumption that plants maintain peak yields is unrealistic in perennial crop production.

2.4 Overview of the Literature

From the literature reviewed, there are several aspects that deserve some scrutiny. Most of the studies reviewed were done outside Kenya and they relate to diversified commodities. Most of the studies concentrated more on the level of national output hence they were not able to capture the factors that influence the level of production at the farm level. In the study by Moore (1917) only price was considered as having an influence on production of products. The study did not consider the influence of other factors such as farmer's level of education, experience and farm size among other factors that influence production in the agricultural sector. Although Askari and Cummings (1976) found that irrigation has a significant effect on the response of farmers to price changes, irrigation is hardly useful in an analysis for coffee production under small-scale farming since under the small-scale coffee farming system irrigation is not a common farm practice. The commodities under discussion were also not specified.

Again, Peterson (1979) highlighted on the factors that take the nature of public goods such as high yielding seed variety whose supply can be increased by public policies and not by price increases. These public policies are not a new phenomenon to the coffee sub-sector. This is evidenced by the new Arabica Ruiru 11 and the liberalization of the coffee sub-sector yet no major improvement has been realized in terms of increase in output. However, the effects of formal schooling and technical training whose effect on small-scale maize farmers was analyzed by Hopcrafts (1974) is worthy analyzing as far as small-scale coffee farming in Gichugu Division is concerned.

Although Murthur (1981) distinguished between the short-run and long-run period supply changes the relativity of the terms short and long-run periods makes an analysis on

coffee production based on the two terms difficult. This brings a problem of knowing the period in which the coffee supply functions for different farmers in Gichugu Division lies. In (1973), Wickens and Greenfield omitted non-price constraints like the family size and the age of the farmer. Antle (1983) also left out the non-price constraints in a study done.

The studies on technology by Harley, Nerlove and Peters (1987), Tomek and Robinson (1991) were done outside Kenya. The effect of technology therefore needs to be analyzed as far as Kenya's agriculture output is concerned and in particular the coffee output by small-scale farmers in Gichugu Division. ✓

The approach employed by Akiyama and Trivedi (1987) is hard to employ in Kenya's coffee industry due to absence of time series data on new planting and replanting as it was noted by Mutunga (1990). Again, Akiyama and Trivedi emphasized on the use of administered producer prices to expand the cocoa industry in Cote d 'ivoire. The producer prices are however hard to fix above world prices for the Kenyan agricultural crops such as tea, coffee and horticultural crops since in Kenya there is no stabilization fund.

The study by Knapp (1987), assumed that production is undertaken primarily for local consumption. It is important to realize that the model used by Knapp is hard to employ in Kenya's coffee sub-sector since local consumption of coffee accounts only for three percent of the total coffee output.

✓ Finally, the study by Dillon and Anderson (1990) is a very general study on the analysis of a farmer's behaviour under the profit maximization. Therefore a more specific study on a coffee farmer's decision-making under the motive of profit maximization would be necessary to determine the extent to which the decision variables influence coffee production.

2.5 Conclusion

Having reviewed the various studies undertaken on the supply response of different crops in different countries, the supply response study by Dillon and Anderson (1990) on a farmer's behaviour under profit maximization was selected as the most appropriate method to estimate the coffee supply function in Gichugu Division. The procedures are detailed in Chapter 3.

CHAPTER THREE

THEORETICAL FRAMEWORK

3.1 Introduction

This chapter presents model specification and sampling techniques. The model specification section describes the theoretical framework and the analytical model that was estimated in an attempt to achieve the objectives of the study. The sampling technique section describes the area of study, the population of interest, the sampling procedure and the research instruments used in the data collection.

3.2 Assumptions

In order to develop the model, the study assumed the following:

- (i) The farmer is the unit of analysis, and his objective is to maximize profits.
- (ii) The farmer supplies all the harvested cherry coffee to the factory and
- (iii) The farmer is a price taker.

3.3 Theoretical Model

Study of a peasant farm technology and efficiency is a theoretical inquiry into the nature of the peasant farmers' household's decision-making process (Anker and Knowles 1983). Knowledge of the objectives and constraints faced by such household including conditions in product and factor markets, is an essential precondition for the correct specification of empirical functions determining production profits, factor demand and choice of technology. A typical farmer combines the consumption and labour supply roles generally performed by the household and management and production roles more commonly performed by the firms. This raises the question about the extent to which

decisions taken in each of these areas affect and is affected by decision taken in the other areas.

According to neoclassical models, each variable input (that is, labour and purchased inputs) is used up to the point where the value of its marginal product is equal to its price (Nakajima 1969). Unfortunately, neither the peculiar institutional characteristics of the farmer nor the market environment in which they operate is built in the neoclassical model. Therefore, a more realistic model of a farmer in Kenya needs to consider the various modifications of the neoclassical model.

Peasant agriculture in Kenya is characterized by high degree of risk or uncertainty due to factors such as irregular rainfall patterns, which cause shocks in production and prices received by farmers. Generally, these factors increase the risk of long-term investments in crops like coffee. Introduction of risk and uncertainty into the neoclassical model leads to a more reasonable objective of utility maximization.

Due to difficulties of developing and analyzing models of production under uncertainty (utility criteria) under the neoclassical model (Dhrymes 1964; Hymans 1966; Sansmo 1971), the farmer is considered as being guided by the need for getting the highest possible profits from his farm activities. This leads to an even more reasonable objective of profit maximization. In this study, a farmer who is the unit of analysis is assumed to be motivated by the maximization of his profits. The farmer is expected to decide on how much to produce in order to maximize his profits depending on the availability of resources. These resources are financial capital for buying inputs and availability of labour. A farmer therefore invests in his farm by putting in more input if he expects a

stream of benefits in the future. The profit maximization motivated farmer decides the amount of output and inputs depending on the prices of output and inputs.

Let the farmers' production function of a farm technology be given by (see Sadoulet and Janvry, 1995):

$$h(q,x,z)=0, \quad (3.1)$$

where q is the vector of output quantities, x is the vector of variable input quantities, and z is a vector of fixed quantities. Variable inputs are usually labour, fertilizer, water, pesticides seeds, hours of rented tractor use that can be purchased in the desired quantities. Fixed factors are either private factors (land, equipment), public factors (infrastructure and extension services), or exogenous features such as weather and distance to market.

If w and p are the prices of inputs and outputs, respectively, the producers restricted profit is " $p'q-w'x$ " (the symbol ' indicates transposition of a vector, and "restricted" profits means that only variable costs are subtracted from gross revenues). Assuming a coffee farmer chooses the combination of variable inputs and output that will maximize profit subject to the technology constraint, a constrained profit-maximizing problem can be specified as:

$$\underset{x,q}{Max} p'q - w'x, \text{ st } h(q,x,z) = 0 \quad (3.2)$$

The solution to this maximization problem is a set of input demand and output supply function that can be written as:

$$x = x(p, w, z) \quad \text{and} \quad q = q(p, w, z) \quad (3.3)$$

Substituting these expressions into the definition of profit gives the profit function, Π , which is the maximum profit that the farmer could obtain given the prices, w and p , the availability of fixed factors, z , and the production technology, h . That is,

$$\Pi = p'q(p, w, z) - w'x(p, w, z) = \Pi(p, w, z) \quad (3.4)$$

From the Shephard duality lemma, differentiating equation (3.4) and taking advantage of the first order conditions of the profit maximization problem (see Equation 3.2), gives the profit function two interesting properties, that is, its derivative with respect to the price of a product is equal to the supply function of that product; and its derivative with respect to the price of an input is equal to the negative of the demand function of that input. Thus,

$$\frac{\partial \Pi(p, w, z)}{\partial p_i} = q_i \quad \text{and} \quad \frac{\partial \Pi(p, w, z)}{\partial w_k} = -x_k \quad (3.5)$$

3.4 Empirical Model

The theory of supply as applied in agriculture seeks to provide an explanation of the level and the fluctuations of the price of agricultural products. Similarly, the farmers' coffee supply is mostly affected by the price per kilogram of coffee supplied and the cost of inputs. By extension as far as a coffee farmer is concerned, coffee output is also determined by many factors, which can be broadly classified into variable input quantities (x) and the fixed factor quantities (z).

The variable inputs included the expenditure on inputs such as fertilizers, pesticides, herbicides, labour and availability of credits to the farmers. The fixed factors included; size of the household, farmer's level of education, number of coffee trees owned

by the farmers, which is fixed in the short run, farmer's off -farm activity, distance from the farm to the factory and output price

Let Q_s be the quantity of cherry coffee supplied by the farmer to the factory, X_1 the output price for coffee, X_2 total expenditure on inputs, X_3 the farm- factory distance, X_4 the credit extension to the farmer, X_5 the size of household, X_6 the farmers level of education, X_7 the number of coffee trees owned and managed by the farmer and X_8 the farmer's off-farm activity.

The profit maximizing coffee supply function for the farmer was therefore be expressed as;

$$Q_s = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8,) \quad (3.6)$$

From the definition of the variables to be used in the analysis shown above, all the variables were quantitative except the variable-farmer's off-farm activity (X_8), which was captured, using a dummy variable. The values 1 and 0 were given to farmers with other source(s) of income and farmers who depend only on coffee, respectively.

Therefore, a linear model of coffee supply may be specified as:

$$Q_s = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \alpha_5 X_5 + \alpha_6 X_6 + \alpha_7 X_7 + \alpha_8 X_8 + e \quad (3.7)$$

where $\alpha_0, \dots, \alpha_8$, are the parameters to be estimated and e is the error term. The error term was based on the following assumptions. First, it is a random variable whose average value is exactly equal to zero at any particular time and has a constant variance. Second, it has a normal distribution. And lastly, it is independent of the explanatory variables (see Gujarati 1995).

Estimation of the supply function will use the ordinary least square (OLS) method. This method was selected for the following reasons. First, it is easy to understand and has

relatively easy data accessibility compared with the difficulty of obtaining more detailed input output and resource data required in other estimation methods such as linear programming. Second, it has relatively low cost and quick aggregative results. Lastly, it has the ability given the satisfaction of certain statistical assumptions underlying the model, to make probability and confidence statements around the results. The method has also been widely applied in various researchers and has given satisfactory results thus giving unbiased estimates and minimum variance.

Furthermore, the method allows for inclusion of non-sample information in the model such as imposing restrictions thus allowing one to choose the better model between the restricted and the unrestricted model.

3.5 Area of study

Gichugu Division is one of the four divisions in Kirinyaga District in Central Province of Kenya. It has an area of 214 square kilometres (Republic of Kenya 1997b). The division has 6 locations namely Kabare, Karumandi, Kirima, Ngariama, Baragwi and Njukiini. The other divisions of the district are Ndia, Mwea and Kutus-Kerugoya municipality. The greater part of the division lies between 2,000 and 4800 m above sea level and it is interspersed with open u-shaped valleys and ridges. The u-shaped valleys provide a good possibility for construction of dams, which can be used for storage of water, for domestic use and irrigation. The division has a tropical type of climate. The pattern of rainfall is typically equatorial since the division is situated within the highlands of Kenya and near the equator. The division experiences two

rainfall seasons, the long rains which occur from March to May, and short rains which occur from October to November.

In the upper parts of Gichugu Division bordering the forest, are found rich fertile red clay soils where tea and dairy farming are also carried out in small scale. Gichugu Division has a high potential for agricultural activities due to its high endowment with fertile soils and favourable climate pattern. The major crops grown in this division are coffee, tea, maize, beans, Irish potatoes, bananas and horticultural crops.

3.6 Sampling Procedure

Kirima, Kabare and Baragwi locations were selected randomly from the six locations in Gichugu Division. From the three locations selected, factories were selected using random sampling technique. First, a list of all coffee factories in the selected locations was made and a random sample of factories was made. Second, a list of all farmers in the randomly selected factories was compiled to determine the population size in each of the selected factories. Finally, farmers to be interviewed were identified using the random sampling procedure. The target was to interview 100 farmers from the whole population.

3.7 Research Instruments

The researcher and a research assistant administered questionnaires (See Appendix 1) to the various respondents. These questionnaires were used to collect data on the dependent and the independent variables shown and defined in Sections 3.3 and 3.6, respectively. The respondents were either the farm owners or the people they have entrusted with their farms.

3.8 Conclusion

Having considered different theoretical frameworks, the constrained profit maximization model by Sadoulet and Janvry (1995) was adopted as the best model to use in the study. The data sources, analysis and estimation results based on the survey data are presented in chapter four.

CHAPTER FOUR

DATA SOURCES, ANALYSIS AND ESTIMATION RESULTS

4.1 Introduction

The purpose of this chapter was to analyze the variables involved in the study and estimate the model described in the previous chapter. In the first two sections, data description and data analysis is presented. The model estimation and the analysis of the results are then discussed. Finally, concluding remarks are made. Data description involved a discussion on the sources of data and definitions of the dependent and the independent variables. Data analysis is divided into graphical analysis and data statistics. The analysis of the results is based on the results from the estimation of the coffee supply function for Gichugu Division specified in Chapter 3.

4.2 Data Description

This section presents sources of data and the definitions for the dependent and the independent variables that are used in the study. The characteristics of the sample are also presented.

4.2.1 Data Sources

The data used in the study are cross-sectional data collected and compiled from the small-scale coffee farmers in Kirima, Kabare and Baragwi locations in Gichugu Division for the 2001 crop year. The data collection procedure was discussed in Chapter 3 and the surveyed data are presented in Appendix 1.

4.2.2 Definition of Variables J

The data collection was made on the following variables: The amount of cherry coffee supplied by the farmer to the factory (Qs); the amount of money in Kenyan shillings received by the farmers from farmers cooperative societies for the 2000 crop year (X1); total expenditure on inputs incurred by the farmer (X2); the distance from the farm to the factory (X3); the credit extended to the farmer in form of loan or cheques for paying school fees (X4); the size of the farmer's household (X5); the highest level of education completed by the farmers (X6); the number of coffee trees owned and managed by the farmer (X7); and the farmer's off-farm activity (X8).

4.3 Data Analysis

This section presents graphical analysis and descriptive statistics of the variables used in the study.

4.3.1 Graphical Analysis

The graphs were based on raw data collected from 67 respondents in Kirima, Kabare and Baragwi locations in Gichugu Division. Each of the independent variable defined in Section 4.2.2 was plotted against the respondents to determine the distribution pattern and to identify any outlier observations. From the plots of variables five outlier observations were identified and hence were removed from the sample. This reduced the sample size from 67 to 62 observations. The variable plots from the raw data after removing the outlier observations are presented below. The variable plots generally revealed that the observations had minimum variance. Plots of the amount of cheery coffee supplied by the farmers to the factory Qs; the amount of money in Kenya shillings

received by the farmers from the cooperative societies for the 2000 crop year (X1); total expenditure on inputs incurred by the farmer (X2); the distance from the farm to the factory (X3); the credit extended to the farmer in form of loan or cheques for paying school fees (X4); the size of the farmer's household (X5); the highest level of education completed by the farmer (X6); the number of coffee trees owned and managed by the farmer (X7); and the farmer's off-farm activity (X8) are presented in Figures 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8 and 4.9 respectively.

Figure 4.1 Coffee supply by small-scale farmers in Gichugu Division for the 2001 crop year

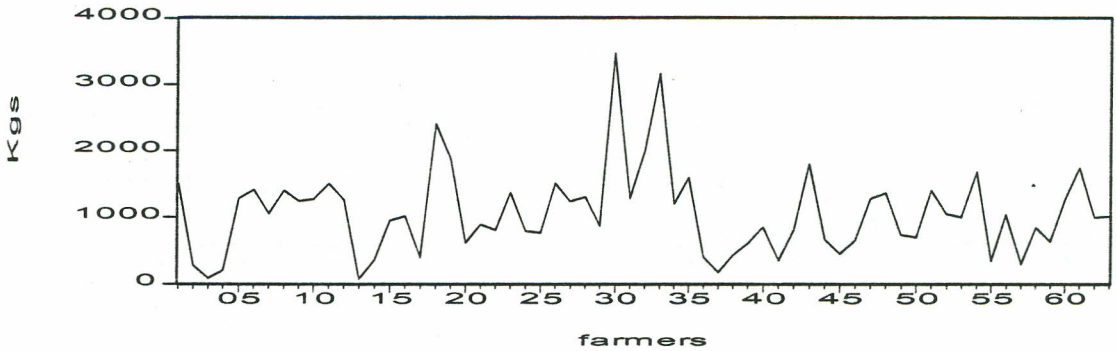


Figure 4.2 Coffee prices received by the farmers from the cooperative societies for 2000 crop year

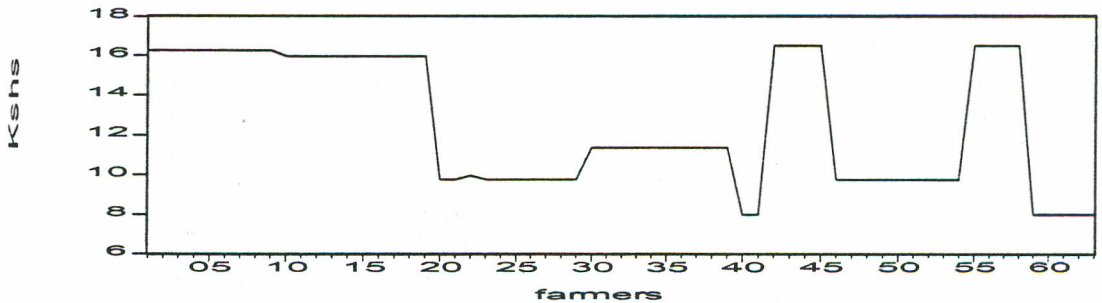


Figure 4.3 Total expenditure on inputs incurred by the farmers

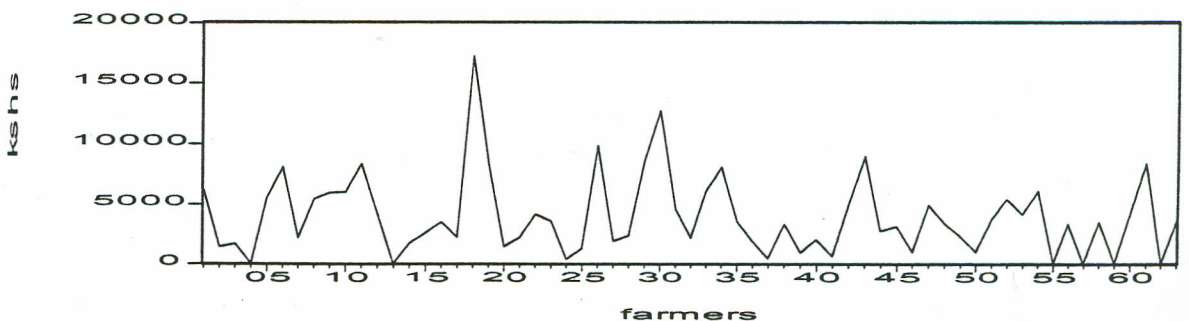


Figure 4.4 The distance from the farm to the factory

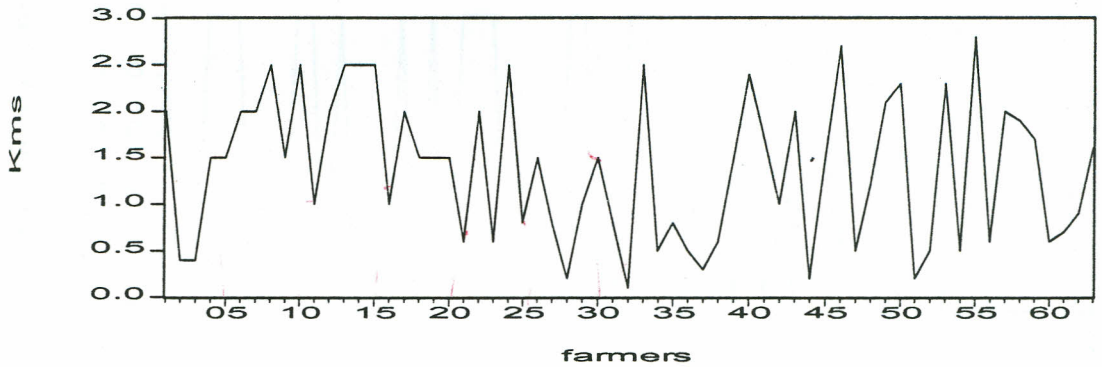


Figure 4.5 Credit extension to farmers inform of loan or school fees

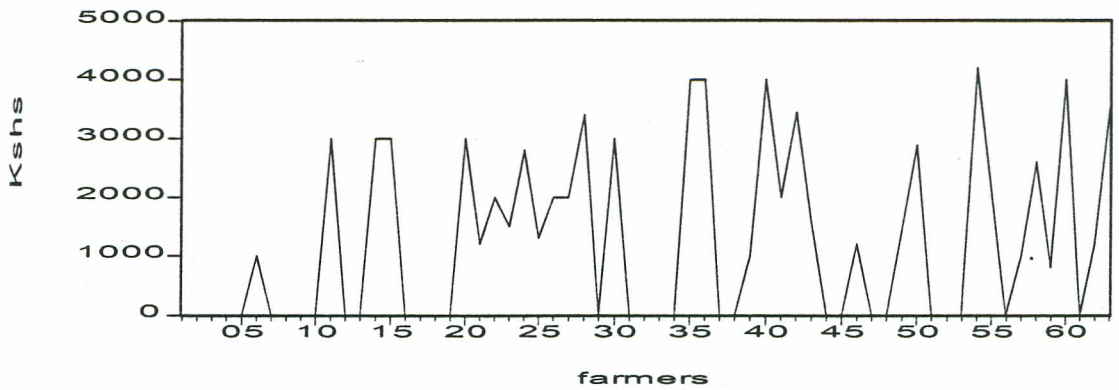


Figure 4.6 Size of the farmer's household

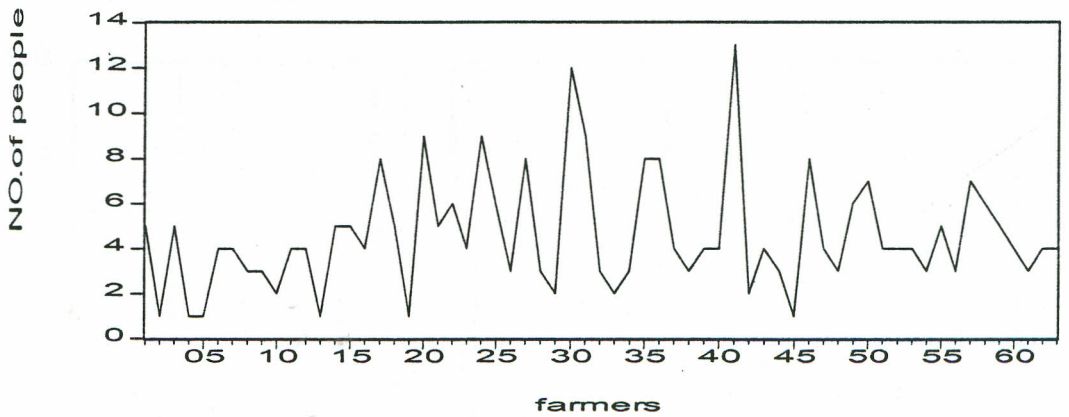


Figure 4.7 Highest level of education completed by the farmer

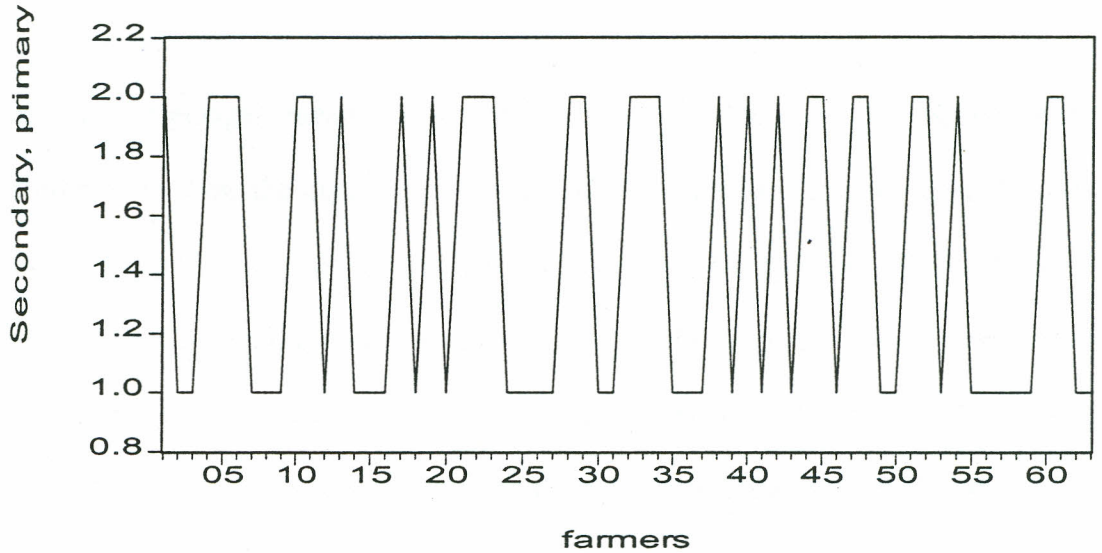


Figure 4.8 Number of coffee trees owned and managed by the farmer

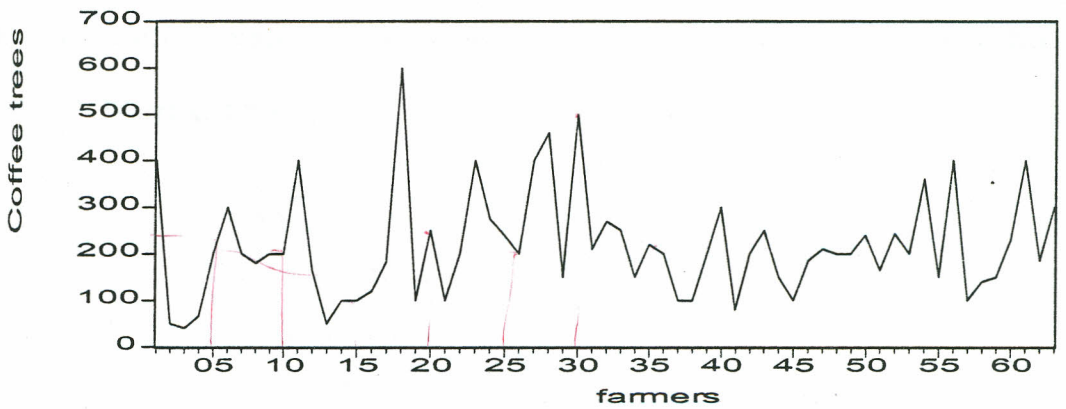
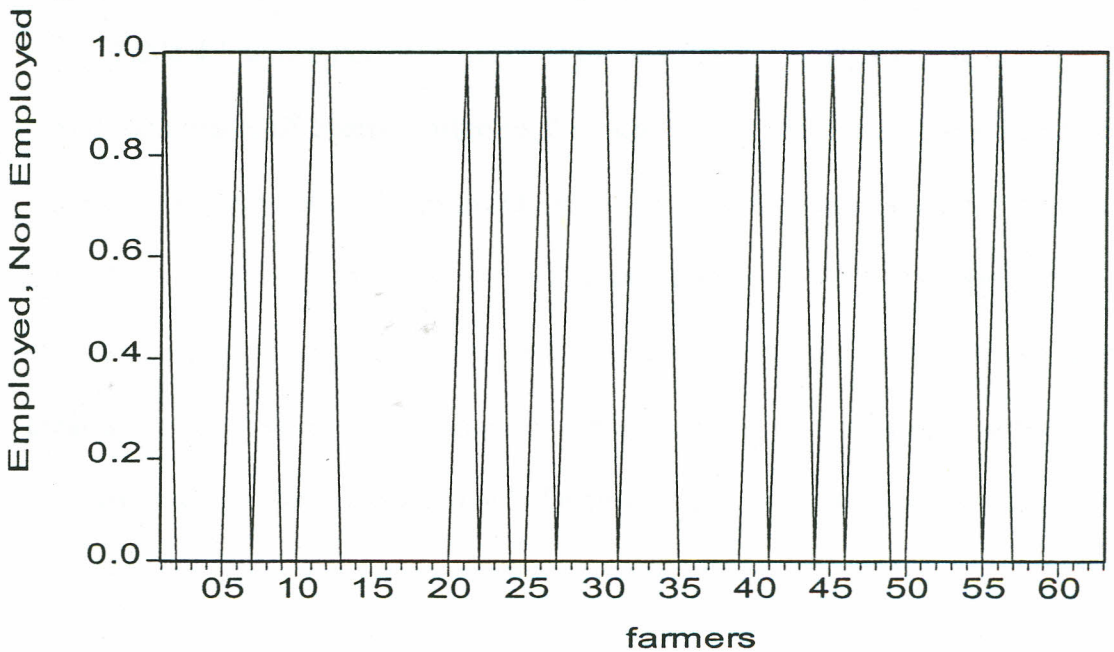


Figure 4.9 The farmer's off-farm activity



4.3.2 Descriptive Statistics

In this section descriptive statistics of the sample are presented. The statistics include percentages, mean and standard deviation of the variables. Moreover tables are presented to show the distribution pattern of the variables. Table 4.1 describes the coffee supply by small-scale farmers in Gichugu Division to the factories. Coffee prices received by the farmers from the cooperative societies for 2000 crop year, total expenditure on farm inputs, the distance from the farm to the factory, the size of the farmer's household, the highest level of education completed by the farmers and the number of coffee trees owned and managed by the farmer are, respectively, presented in Tables 4.2, 4.3, 4.4, 4.5 and 4.6.

Table 4.1 Coffee supply by small-scale farmers in Gichugu Division; Kirinyaga District, 2001

No. of kilograms	No. of Farmers	Percentage
0-1000	31	50
1001-2000	29	47
2001-3000	1	1.5
Above 3000	1	1.5
Total	62	100

Table 4.1 shows that 50 percent of the farmers in Gichugu Division supply between 0-1000 kilograms of cherry coffee to the factory per crop year while 47 percent supply between 1001 and 2000 kilograms. Only 3 percent of the farmers supply more than 2000 kilograms of coffee to the factory. The mean number of kilograms supplied was 1025.8 kilograms with a standard deviation of 597.9. The standard deviation shows that there is a great dispersion between the amount of coffee supplied by the farmers to the factory and the mean supply. The dispersion could be attributed to differences in the number of coffee

trees owned by the farmers (Table 4.6) plus other factors such as differences in expenditure on farm inputs.

Table 4.2 Coffee price received by the farmers in Gichugu Division from the cooperative societies for the 2000 crop year

Price (Ksh)	No. of Farmers	Percentage
0-5.5	0	0
5.6-10.5	26	42
10.6-15.5	9	15
15.6-20.5	27	43
Total	62	100

The study shows that 42 percent of the farmers receive less than ten Kenya shillings and fifty cents per kilogram of coffee supplied while 15 percent of the farmers receive between ten Kenya shillings and sixty cents and fifteen Kenya shillings and fifty cents. Only 43 percent of the farmers receive more than fifteen Kenya shillings and fifty cents. The mean price of coffee was Ksh 12.6 with a standard deviation of 3.1. The mean price identified is too low to motivate the farmers to invest in their coffee farms as compared to the national annual average price of Kenya shillings 104.3 for the 1985 to 2000 crop years (Republic of Kenya Various Issues). The standard deviation of 3.1 implies that there is relatively little dispersion from the mean price among the factories in Gichugu Division.

Table 4.3 Total expenditure on farm inputs incurred by the farmers in Gichugu Division

Input cost (Ksh)	No. of Farmers	Percentage
0-2000	26	42
2001-4000	17	27
4001-6000	9	15
Above 600	10	16
Total	62	100

Table 4.3 summarizes the total expenditure on inputs in Kenya shillings. It can be observed that 42 percent of the coffee farmers spent less than 2000 Kenya shillings on farm inputs such as fertilizers while 27 percent of the farmers allocated between 2001 and 4000 Kenya shillings on the same. Fifteen (15) percent of the farmers spent between 4001 and 6000 Kenya shillings on the farm inputs. And finally, only 16 percent of the farmers used more than 6000 Kenya shillings worth of the resources on inputs. The expenditure on inputs implies that the farmers are aware of the importance of farm inputs such as fertilizers and spraying chemicals, which were the major inputs used in the coffee farms. The mean expenditure on inputs was Ksh. 3868.9 with a standard deviation of 3328. The large standard deviation from the mean expenditure shows the wide dispersion that is there among the farmers as far as spending on farm inputs is concerned. This could be due to the difference in the number of coffee trees owned by the farmers (Table 4.6) and differences in sources of incomes that can be used to supplement the coffee subsector in Gichugu Division.

Table 4.4 Distance from the farm to the factory for the farmer

Distance (kilometres)	No. of Farmers	Percentage
0-2	50	81
Above 2	12	19
Total	62	100

The study showed that 81 percent of the respondents supply their coffee to factories that are less than 2 kilometres from their farms while only 19 percent supply their coffee more than 2 kilometres away from their farms. The mean distance was 1.36 kilometres with a standard deviation of 0.77. The standard deviation shows that there is very little dispersion from the mean distance among the coffee farmers in Gichugu Division. The mean distance of 1.36 kilometres is quite manageable for the farmers. This implies that factories therefore are evenly distributed within the division. In other words the factories can be easily accessed.

Table 4.5 The size of the farmer's household

No. of people	No. of farmers	Percentage
0-5	46	74
6-10	14	23
10-15	2	3
Total	62	100

Table 4.5 shows that 74 percent of the families have less than five (5) members while about 23 percent have between six (6) and ten (10) family members. Only three percent of

the households have more than ten (10) members. The average family size was five members with a standard deviation of three. The average family size shows that there is at least some manpower to be used in the coffee farms for every coffee farmer. In the Kenyan culture, the use of family labour is quite common especially in the small-scale farming.

Table 4.6 Number of coffee trees owned and managed by the farmer

No. of coffee trees	No.of farmers	Percentage
0-250	47	76
251-500	14	22.5
Above 500	1	1.5
Total	62	100

Table 4.6 showed that 76 percent of the farmers own less than 250 coffee trees while 22.5 percent of the farmers own between 251 and 500. Only 1.5 percent of the farmers own more than 250 coffee trees. The mean coffee trees were 216 with a standard deviation of 116. The standard deviation of 116 from the mean number of coffee trees owned is, however, relatively large due to the relative differences in the sizes of the farmers' farms.

The Highest level of education completed by the farmer

The study revealed that 45 percent of the farmers have gone through secondary education while the remaining 55 percent have only completed primary education. With at least every farmer having attained some basic education, it implies that, the farmers have no problems in farm practices such as coffee spraying as long as the spraying chemicals are provided at affordable prices.

Credit extension to the farmer in form of loan or cheques for paying school fees

The study shows that 52 percent of the farmers in Gichugu Division get credit in form of cheques to pay for their children's school fees and 48 percent never borrow from the factories. The mean credit was Ksh. 1244 with a standard deviation of 1438.1. The large standard deviation of credit from the mean credit shows that there is a large dispersion between the farmers' borrowings from the factories in the form of loans and cheques for paying school fees. This dispersion is expected to be there since some farmers depend only on coffee while others have other sources of income and thus it is not a must for them to borrow money from the factories to finance their needs such as paying for their children's school fees.

Farmer's off-farm activity

The study revealed that 45 percent of the farmers have other jobs apart from farming and 55 percent of the farmers only depend on coffee. With more than half of the farmers depending only on coffee, it implies that majority of them earn about Kenya shillings 12925.08 per year. This is equivalent to Kenya shillings 35.4 (0.45 Dollars) per day. This implies that poverty is prevalent among the households in Gichugu Division.

4.4 Model Estimation

This section presents the results of regression model specified in Chapter 3. Moreover, diagnostic tests are presented such as calculating correlation between variables and plotting the residuals from the different versions of the model. The estimation results of the linear models are presented in Tables 4.7(a), (b), (c) and (d). The correlation coefficient is presented in Appendix 2 while plots of residual are presented in Appendix 3.

Four versions of the model were estimated. These are regressions for all the variables in equation 3.7; regression for equation 3.7 without the variable X6; regression of equation 3.7 with a one-year price lag and regression of equation 3.7 with a one-year price lag without X6. The results presented include the variable coefficients, standard error, t-ratio, coefficient of determination (R^2), Durbin Watson statistic and F-statistic.

A correlation matrix for all the variables in the model was generated to test the degree of multicollinearity (see Appendix 2). The results of the correlation matrix showed that the degree of multicollinearity between variables included in the model was not high. However, it was observed that the farmer's level of education (X6) is moderately correlated with the farmer's off- farm activity (X8). Also, the two variables (X6 and X8) did not display much variation and X6 is insignificant as shown in Tables 4.7a and 4.7c.

Prior to the regression analysis, graphical analysis was done, that is, all the variables were plotted against the observations to identify any outliers. All the outliers were removed and then the regression analysis was done. The residuals from the regression estimation were also plotted on scatter diagrams to identify whether heteroskedasticity is present (See Appendix 3(a), (b), (c) and (d)). Most of the residuals were clustering around zero implying that the data were homoskedastic, which is a major assumption of the ordinary least squares method.

Table 4.7(a) Regression results of equation 3.7 all variables

Independent variable	Coefficient	Std. error	t-ratio
C	265.6940	338.6187	0.7846
X1	-4.4100	16.0530	-0.2747
X2	0.1017	0.0168	6.0454***
X3	-25.1153	60.2967	-0.4165
X4	-0.0124	0.0342	-0.3631
X5	25.4455	22.9664	1.1079
X6	-53.7147	103.4799	-0.5191
X7	1.5606	0.4949	3.1534***
X8	210.1696	111.6001	1.8832*

Note: *** significant at 1%; ** significant at 5% and * significant at 10%

R-squared=0.738793

Adjusted R-squared=0.699365

Durbin-Watson statistic=2.453602

F-statistic=18.73800

(b) Regression results of model (a) without X6

Independent variable	Coefficient	Std. error	t-ratio
C	158.3061	266.2539	0.5946
X1	-3.6775	15.8823	-0.2315
X2	0.1013	0.0167	6.0677***
X3	-20.5480	59.2463	-0.3468
X4	-0.0121	0.0340	-0.3567
X5	29.8599	21.1891	1.4092
X7	1.5612	0.4915	3.1762***
X8	198.7152	108.6543	1.8289*

Note: *** significant at 1%; ** significant at 5% and * significant at 10%

R-squared=0.737465

Adjusted R-squared=0.703432

Durbin-Watson statistic=2.451246

F-statistic=21.66953

(c) Regression results of equation 3.7 with a one-year price lag

Independent variable	Coefficient	Std. error	t-ratio
	166.3288	357.6587	0.4650
X1(-1)	0.1958	16.7959	0.0117
X2	0.0996	0.0167	5.9743***
X3	-23.7065	62.5650	-0.3789
X4	-0.0149	0.0361	-0.4114
X5	29.0410	22.7944	1.2740
X6	-42.7253	106.2237	-0.4022
X7	1.6259	0.5105	3.1850***
X8	225.4713	115.5042	1.9521*

Note: *** significant at 1%; ** significant at 5% and * significant at 10%

R-squared=0.736808

Adjusted R-squared=0.696317

Durbin-Watson statistic=2.454606

F-statistic=18.19684

(d) Regression results of model (c) without X6

Independent variable	Coefficient	Std. error	t-ratio
C	75.1339	274.4154	0.2738
X1(-1)	1.0533	16.5278	0.0637
X2	0.0991	0.0165	6.0088***
X3	-19.7019	61.2772	-0.3215
X4	-0.0149	0.0359	-0.4158
X5	32.6568	20.7806	1.5715
X7	1.6331	0.5061	3.2268***
X8	218.3361	113.2277	1.9283*

Note: *** significant at 1%; ** significant at 5% and * significant at 10%

R-squared=0.735990

Adjusted R-squared=0.701120

Durbin-Watson statistic=2.456547

F-statistic=21.10709

4.5 Analysis of Results

This section presents a discussion from the regression results. The discussion is based on the consistency of the sign of the coefficient and the statistical test for the linear model. The log-linear model was not used because of the following reasons: It gave a negative coefficient for price for the four versions of the model; and there is a big number of zero observations in the data. Therefore, the linear form of the model is used in all estimations. As far as agricultural products are concerned the current prices usually influence the next period's supply. On the basis of this argument, a one-year price was used instead of the current prices in model (c) and (d). This move made the coefficient for price positive which is consistent with theory (see Table 4.7(c) and (d)) unlike when current prices are used which gave a negative coefficient for price (see Table 4.7(a) and (b)).

The regression results for model (a) showed a negative coefficient for coffee price. The coefficient for the variables X2 and X7 had the expected sign and were statistically significant at 1 percent level of confidence. Coefficient for X8 was also as expected and statistically significant at 10 percent level of confidence. The coefficients for the variables X3, X4 and X5 also had the expected signs though the variables were insignificant. However, the variables X1 and X6 did not have the expected signs and hence the model was modified as shown in model (b).

Model (b) is another version of model (a) after removing the variable X6. In model (b) the coefficients for the variables X2 and X7 had the expected sign and were statistically significant at 1 percent level of confidence while X8 was statistically significant at 10 percent level of confidence. However, despite the removal of X6 from model (a), the coefficient for coffee price (X1) still remained negative, which is against the prior

expectation as well as economic theory of supply, which says there is a positive relationship between the price of a commodity and its quantity supplied. In an effort to solve the anomaly in the coefficient for coffee price, the one-year price lag ($x-1$) was used instead of X_1 . This resulted to estimation of model (c).

Model (c) gave a positive coefficient for price. The coefficients for the variables X_2 and X_7 had the expected signs and were statistically significant at 1 percent level of confidence. The variable X_8 also remained correctly signed and significant at 10 percent level of confidence. The variables X_3 , X_4 and X_5 were also correctly signed though they were not statistically significant. Despite the one-year lag in price, the variable X_6 had a negative sign which was not expected.

All the regression versions had an equal coefficient of determination of about 0.74 and an adjusted R^2 of 0.70. The Durbin Watson statistic was also the same for all the versions (2.45). The F-statistic also showed a very small range for all the estimated versions of the model (between 18 and 21). From the regression results presented in Tables 4.7(a), (b), (c) and (d), the linear model for the selected variables (See Table 4.7d) gave the best results in terms of the coefficient of determination R^2 , the F-ratio and the signs for the coefficients. All the signs of the linear estimated model were correct (consistent with theory). Three of independent variables such as total expenditure on inputs (X_2); number of coffee trees owned and managed by the farmer (X_7); and farmer's off-farm activity (X_8); also pass the significance test. The Durbin Watson of 2.45 showed absence of serial correlation. Therefore the linear model for the selected variables whose results are presented in Table 4.8(d) was adopted as the suitable model for the analysis.

According to model (d), (Table 4.7d), the regression output for the linear function shows that the independent variables in this equation explain 74 percent of the variations in the coffee supply. The F-value of 21.107 is significant indicating there is a significant linear relationship between the independent variables and the coffee supplied by a farmer per crop year. The following is a discussion of each variable with regard to sign, significance and possible policy implications.

The coffee price received by the farmer for the 2000 crop year [X1 (-1)]

Output price was statistically insignificant with a t-ratio of 0.0637. This implies that since most of the farmers under study are small-holders, they do not have a lot of alternatives, hence coffee prices do not seem to influence their decisions. The variable had a positive coefficient of 1.053, indicating that a one-unit increase in the price paid to the farmer increases coffee supplied, which is consistent with theory, since supply function is non-decreasing in output prices.

The total expenditure on inputs (X2)

The total expenditure on inputs was the most significant variable influencing coffee supply, as shown by a t-ratio of 6.008. The coefficient of this variable is positive suggesting that one-unit increase in use of inputs yields a 0.099 units increase in the amount of coffee supplied. The higher the expenditure the higher the supply. It is therefore evident that investing more in terms of farm inputs such as fertilizers and farm chemicals, which were used to measure the expenditure on inputs, is very important in coffee production.

Distance from the farm to the factory distance (X3)

Distance from the farm to the factory had a negative coefficient (19.70) and statistically insignificant. The negative coefficient, which was as expected implies that a one-unit increase in distance from the farm to the factory decreases coffee supply by 19.7 units. Although, again, this influence is not significant

Credit extension to farmers in form of loan or cheques for school fees (X4)

Credit extension had a negative coefficient suggesting that a unit increase in the amount of credit extended to the farmer reduces coffee supply by 0.014 units. This variable was measured in terms of money lent to the farmer in form of loan or school fees. The negative coefficient can be explained by the fact that this credit is given at the expense of farm inputs since a farmer is unlikely to get credit in form of a loan or school fees and farm inputs simultaneously. Once a farmer has borrowed in form of a loan or school fees it becomes hard to borrow in form of farm inputs to invest in the coffee farm. Moreover the farmer gets little money as most of what one could get goes to the repayment of the loan hence the farmer becomes less motivated to work in his coffee farm. The coefficient was, however, insignificant (t-ratio 0.41).

Size of the farmer's household (X5)

The size of a household factor had a positive coefficient implying that the larger the household, the more the coffee supply. Specifically, an additional one-person increase in household size would increase the coffee supplied by 32.65 units. This revealed that coffee is a labour-intensive crop and the larger the family, the more the labour that can be used in the coffee farming. However, the t-ratio of 1.57 indicated that the variable was statistically insignificant.

Number of coffee trees owned and managed by the farmer (X7)

Number of coffee trees owned by the farmer was a significant determinant of coffee supply as shown by a t-ratio of 3.22. This implies that the number of coffee trees influences the supply of coffee, as one would expect from theory. The coefficient was positive suggesting that a one unit increase in number of coffee trees owned by the farmer increases coffee supply by 1.63 units.

Farmer's off-farm activity (X8)

A dummy captured the effect of a farmer's off-farm activity. Farmer's off-farm activity was a significant factor in coffee supply at ten (10) percent level of significance (a t-ratio of 1.92). This means that assuming the other variables constant, farmers with other job(s) supply 218.3 units of coffee higher than those without other job(s). This indicates that coffee supply differentials based on farmer's off-farm activities are in favour of those farmers with other jobs.

4.6 Conclusion

To achieve the objectives of the research, both descriptive and inferential statistics were used. Descriptive statistics were used to find out the percentages, mean and standard deviations of the variables. Inferential statistics on the other hand were used to analyze statistical results of the estimation model specified in Chapter 3. The R^2 was found to be about 0.74, which implied that about 74 percent of the variation in coffee supply in Gichugu Division could be explained by the independent variables used in the estimation model. In the next chapter the implications of the study findings are discussed.

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Summary

The main objective of this study was to investigate the factors that determine the supply of coffee in Gichugu Division. To achieve the objective of the study, cross sectional data were collected using structured questionnaire from a sample of 67 respondents. The data were inspected for any outlier variables where five outlier variables were identified. The outliers were removed hence the sample size reduced to 62 respondents. Data were then analyzed using both descriptive and inferential statistics.

The review of the government policies revealed that a number of policies had been implemented since 1896 when coffee was introduced in Kenya. These policies were aimed at enhancing the performance of the coffee sub-sector in terms of increasing production and hence higher incomes for the coffee farmers.

Using the collected data, the study revealed that about 97 percent of the farmers supplied less than 2000 kilograms of coffee to the factories per crop year (see Table 4.1). The average supply was 1025.8 kilograms. Weighting the average supply by the average price, which was Kenya shillings 12.6 showed that farmers earn an average of about Kenya shillings 12,925 from coffee per crop year. This is very low given that these earnings included only the actual costs of coffee supplied by the farmer. This makes it difficult for the farmer to have enough funds to reinvest in their coffee farms in form of inputs in order to increase coffee production. Most of the farmers, therefore, end up putting very little inputs, hence the low coffee supplies.

Furthermore, the study found that total expenditure on inputs is the most statistically significant variable in the determination of coffee supply. The other significant variables were number of coffee trees and farmer's off-farm activity. The rest of the variables in the linear estimation (see Table 4.7d) were insignificant. These included farm factory distance and credit extension, which had a negative effect on coffee supply and price of coffee and household size, which had a positive effect on coffee supply. In this study R^2 was explaining 74 percent of the variations in the determination of coffee supply. Other variables such as factory operations costs and payment system can partly explain part of the remaining variation.

5.1 Policy recommendations

On the basis of the study findings, the following policy recommendations arose

The survey showed that inputs use is the most important factor that determines coffee supply by the farmers. Most of the respondents used fertilizers, fungicides and pesticides with some not knowing the name of the fertilizers and the chemicals they used but only knowing how much they paid for them. It is therefore recommended that awareness campaigns should be enhanced through seminars and conferences to inform the farmers, what type of fertilizers and chemicals to apply, when, how and why to apply them. This would help the farmers to know which farm input is required at different stages of coffee growing for their effective utilization and hence higher coffee supply.

Furthermore, 55 percent of the farmers' respondents are engaged only in coffee farming with no other income-generating activities. This implies that majority of the coffee farmers in Gichugu Division depend only on coffee to meet needs such as clothing, construction of shelter and paying of school fees. This forces farmers to borrow to finance

their needs instead of investing in their coffee farms and thus the low coffee supply. To reduce this over-reliance on coffee whose prices keep fluctuating, farmers should diversify their farm activities to include little space consuming farm activities such as poultry keeping, and zero grazing. This would help in providing food as well as finances to cater for other needs such as paying of school fees where the surplus is sold.

Since farmers may not be able to increase the number of their coffee trees due to land scarcity, it is recommended that farmers should desist from cutting down their coffee which has become a common practice among the farmers in Gichugu Division so as to plant food crops such as maize. Instead, the farmers should diversify their agricultural activities to include little space consuming agricultural practices such as poultry keeping and improve on their zero grazing methods. This would help in provision of funds for family needs such as payment of school fees and buying of food to supplement the little that farmers get from their farms. The Ministry of Agriculture should also advise farmers on some suitable food crops that can be inter-cropped with coffee if any to ensure that coffee is not uprooted or cut down at the expense of food crops.

5.2 Limitations of the study

In this study, several problems were experienced. First, most of the farmers did not have any records on their farm practices hence most of the information was based on the farmer's recall faculty. Second, some respondents were reluctant to give the information required with the fear that one could use the farm details to borrow some loan using their farm accounts. Farmers were in particular reluctant to give information on their family size since it is termed as a taboo to count one's children.

5.3 Suggestion for further research

The present study was conducted in Gichugu Division in Kirinyaga district in the Central Province of Kenya. It is suggested that a more elaborate research cutting across other different coffee growing areas be undertaken to investigate further the determinants of coffee supply. This will help confirm whether the results of this study are applicable in other coffee growing areas. Also, apart from the cross sectional data, time series data should be used in order to see the impact of trade liberalization of the coffee on coffee supply. A survey on the other factors such as marketing of coffee should be carried out to determine the effect and extent to which coffee marketing affects coffee supply.

A

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APPENDIX 1 SURVEY DATA AND QUESTIONNAIRE

A. Survey Data, Gichugu Division (Location: Kirima, Kabare, Baragwi) June

2002

Qt	X1	X2	X3	X4	X5	X6	X7	X8
1500	16.25	6180	2	0	5	2	400	1
270	16.25	1400	0.4	0	1	1	50	0
81	16.25	1650	0.4	0	5	1	40	0
200	16.25	0	1.5	0	1	2	66	0
1276	16.25	5500	1.5	0	1	2	200	0
1406	16.25	8075	2	1000	4	2	300	1
1050	16.25	2140	2	0	4	1	200	0
1400	16.25	5400	2.5	0	3	1	180	1
1239	16.25	5940	1.5	0	3	1	200	0
1266	15.95	6020	2.5	0	2	2	200	0
1500	15.95	8335	1	3000	4	2	400	1
1250	15.95	4140	2	0	4	1	165	1
65	15.95	0	2.5	0	1	2	50	0
348	15.95	1700	2.5	3000	5	1	100	0
946	15.95	2600	2.5	3000	5	1	100	0
1008	15.95	3515	1	0	4	1	120	0
389	15.95	2185	2	0	8	2	182	0
2406	15.95	17,240	1.5	0	5	1	600	0
1868	15.95	8280	1.5	0	1	2	100	0
609	9.75	1400	1.5	3000	9	1	250	0
890	9.75	2160	0.6	1200	5	2	100	1
800	9.95	4100	2	2000	6	2	200	0
1364	9.75	3560	0.6	1500	4	2	400	1
786	9.75	360	2.5	2800	9	1	275	0
759	9.75	1260	0.8	1300	6	1	240	0
1506	9.75	9835	1.5	2000	3	1	200	1
1234	9.75	1860	0.8	2000	8	1	400	0
1300	9.75	2330	0.2	3400	3	2	460	1
864	9.75	8515	1	0	2	2	150	1
3468	11.35	12,680	1.5	3000	12	1	500	1
1280	11.35	4570	0.8	0	9	1	210	0
2000	11.35	2120	0.1	0	3	2	270	1
1200	11.35	8055	0.5	0	3	2	150	1
1594	11.35	3535	0.8	4000	8	1	220	0
400	11.35	1900	0.5	4000	8	1	200	0
168	11.35	400	0.3	0	4	1	100	0
426	11.35	3310	0.6	0	3	2	100	0
606	11.35	900	1.5	1000	4	1	200	0
848	8	2000	2.4	4,000	4	2	300	1
346	8	600	1.7	2000	13	1	80	0
808	16.5	4950	1	3450	2	2	200	1
1800	16.5	8920	2	1600	4	1	250	1
664	16.5	2680	0.2	0	3	2	150	0
446	16.5	3115	1.5	0	1	2	100	1

649	9.75	950	2.7	1200	8	1	185	0
1276	9.75	4900	0.5	0	4	2	210	1
1360	9.75	3400	1.2	0	3	2	200	1
734	9.75	2260	2.1	1400	6	1	200	0
693	9.75	950	2.3	2890	7	1	240	0
1396	9.75	3700	0.2	0	4	2	165	1
1042	9.75	5400	0.5	0	4	2	243	1
996	9.75	4100	2.3	0	4	1	200	1
1676	9.75	6055	0.5	4200	3	2	360	1
341	16.5	0	2.8	2100	5	1	150	0
1034	16.5	3310	0.6	0	3	1	400	1
291	16.5	0	2	1000	7	1	100	0
843	16.5	3450	1.9	2600	6	1	140	0
631	8	0	1.7	800	5	1	150	0
1261	8	4150	0.6	4000	4	2	230	1
1743	8	8335	0.7	0	3	2	400	1
994	8	0	0.9	1200	4	1	185	1
1011	8	3500	1.6	3500	4	1	300	1

Note:

Q_s = the amount of cherry coffee supplied by the farmer to the factory; X_1 = the amount of money in Kenya shillings received from the cooperative societies by the farmers from Gichugu Division for 2000 crop year; X_2 = total expenditure on inputs incurred by the farmer; X_3 = the distance from the farm to the factory; X_4 = credit extension to the farmer in form of loan or cheques for paying school fees; X_5 = the size of the farmer's household; X_6 = the highest level of education completed by the farmers; X_7 = number of coffee trees owned and managed by the farmer and X_8 = farmer's off-farm activity.

B. Farmers Questionnaire

The main objective of this questionnaire will be to collect data on the factors that determine coffee production by the small-scale farmers in Gichugu Division for a Kenyatta University research paper. Information given will be treated confidentially and will only be used for the purpose of this study. For reliability of the data only the farm owner or the person to whom the farm has been entrusted will be interviewed.

Interview date: _____

Name of interviewer: _____

Respondent number: _____

1.0 Identification

(a) What is your name? (optional) _____

(b) What is your factory membership number? _____

2.0 Education background

(a) What is the highest level of education completed?

Primary

Secondary

College / University

Post University

3.0 Farm details and practice

(a) For how long have you been a coffee farmer? _____ Years.

(b) What is the distance from your farm to the factory? _____ Kilometres

(perceived).

(c) How many coffee trees do you have? _____ Trees.

(d) Do you have any other occupation apart from being a farmer?

Yes No

(e) How many kilograms of coffee did you supply to the factory last year? (2001)
_____ kilograms.

(f) How much were you paid by your society for the year 2000 crop? _____

Kenya shillings.

4.0 Dependency

How many people were staying with you during the previous crop year? (2001 _____).

5.0 Expenditure on inputs

(The answers to these questions will be summarized in Table 1)

(a) Did you use any input in your coffee farm in the year 2000?

Yes

No

(b) If yes fill Table 1

Table 1
Input prices

Raw material (input)	Quantity	Unit price	Total cost

6.0 labor

(The answer to this question will be summarized in Table 2)

(a) How many employees did you have in your farm in the year 2001? (including family members) —

(b) How much did you pay them in total during that year?

Table 2

Employees information

Type of employee	Number of employees	Total payment
Family		
Hired		
Others (specify)		

7.0 Credit extension

Did you borrow any money from your society in form of loan or school fees during the year 2001?

Yes No

If yes, how much?—

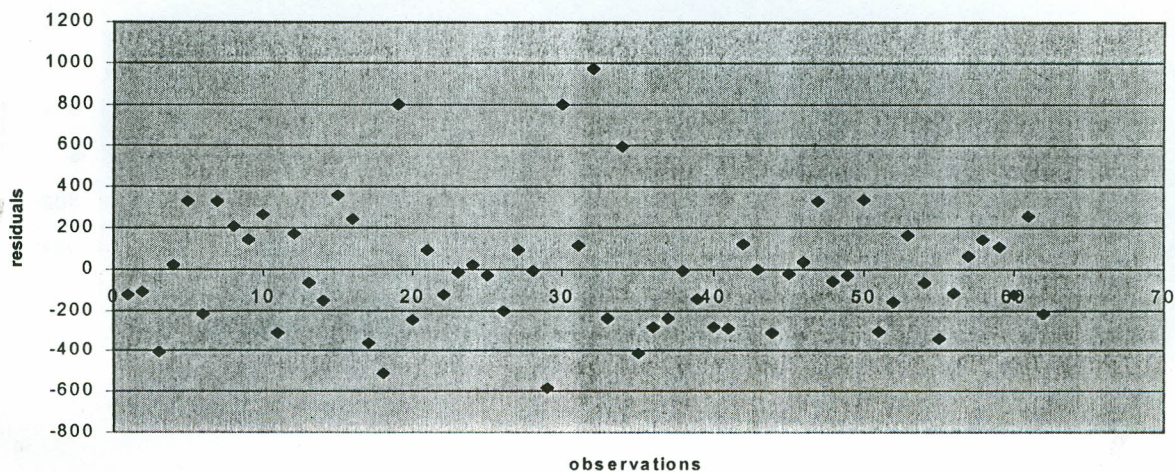
APPENDIX 2

CORRELATION MATRIX FOR ALL VARIABLES

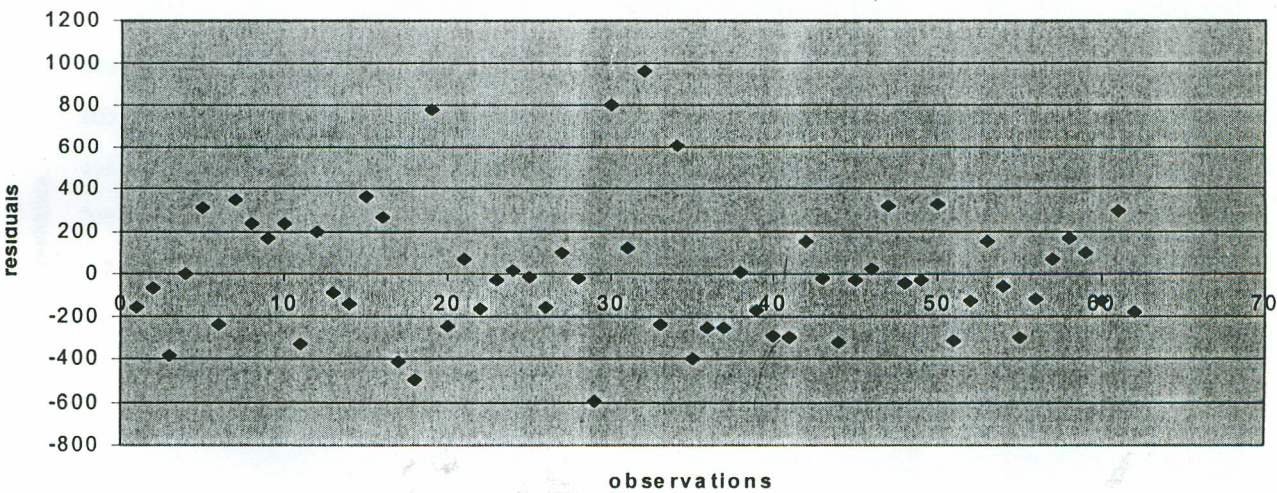
	X1	X2	X3	X4	X5	X6	X7	X8
X1	1.000000	0.138512	0.260055	-0.319030	-0.322933	-0.028290	-0.203519	-0.245812
X2	0.138512	1.000000	-0.073748	-0.091284	-0.125386	0.187319	0.538307	0.381811
X3	0.260055	-0.073748	1.000000	0.102375	0.175827	-0.290389	-0.123432	-0.265126
X4	-0.319030	-0.091284	0.102375	1.000000	0.395106	-0.161031	0.269360	0.050271
X5	-0.322933	-0.125386	0.175827	0.395106	1.000000	-0.488950	0.180583	-0.296759
X6	-0.028290	0.187319	-0.290389	-0.161031	-0.488950	1.000000	0.063720	0.413866
X7	-0.203519	0.538307	-0.123432	0.269360	0.180583	0.063720	1.000000	0.381251
X8	-0.245812	0.381811	-0.265126	0.050271	-0.296759	0.413866	0.381251	1.000000

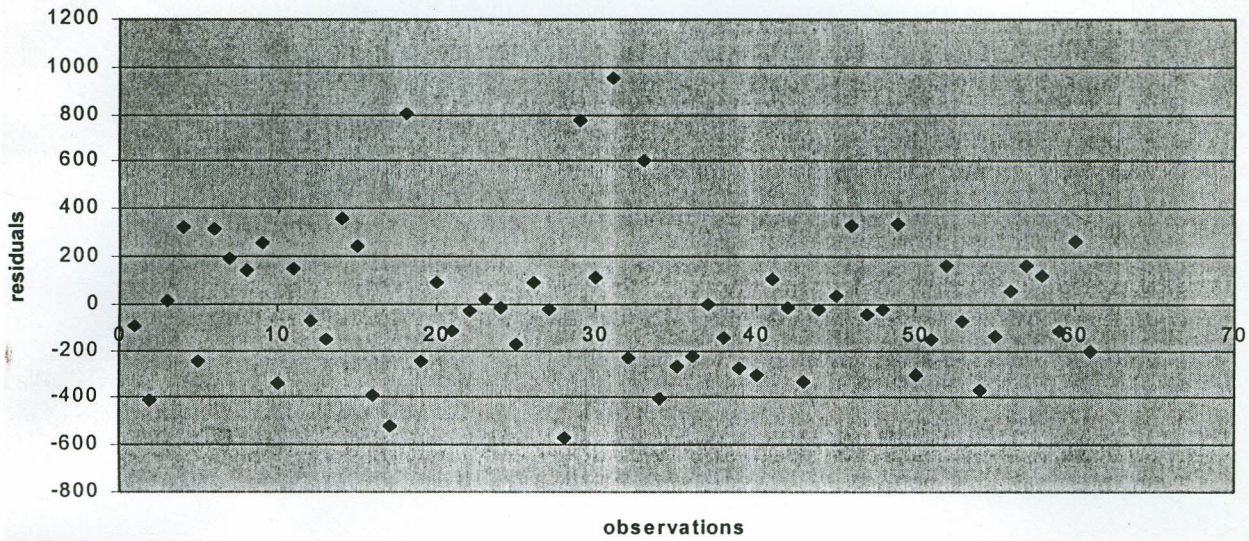
APPENDIX 3: PLOTS OF RESIDUALS

(a) Plot of residuals for model A



(b) Plot of residuals for model B



(c) Plot of residuals for model C**(d) Plot of residuals for model D**